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THESIS – THÈSE

Title of Thesis – Titre de la thèse
Potential Watershed Management Conflicts in the upper North Saskatchewan Basin.

Degree for which thesis was presented Grade pour lequel cette thèse fut présentée Master of Science	Year this degree conferred Année d'obtention de ce grade 1985
University – Université University of Alberta.	Name of Supervisor – Nom du directeur de thèse Dr. A.H. Laycock.

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Potential Watershed Management Conflicts in the Upper North Saskatchewan Basin

by

©

Brian M. Kelly

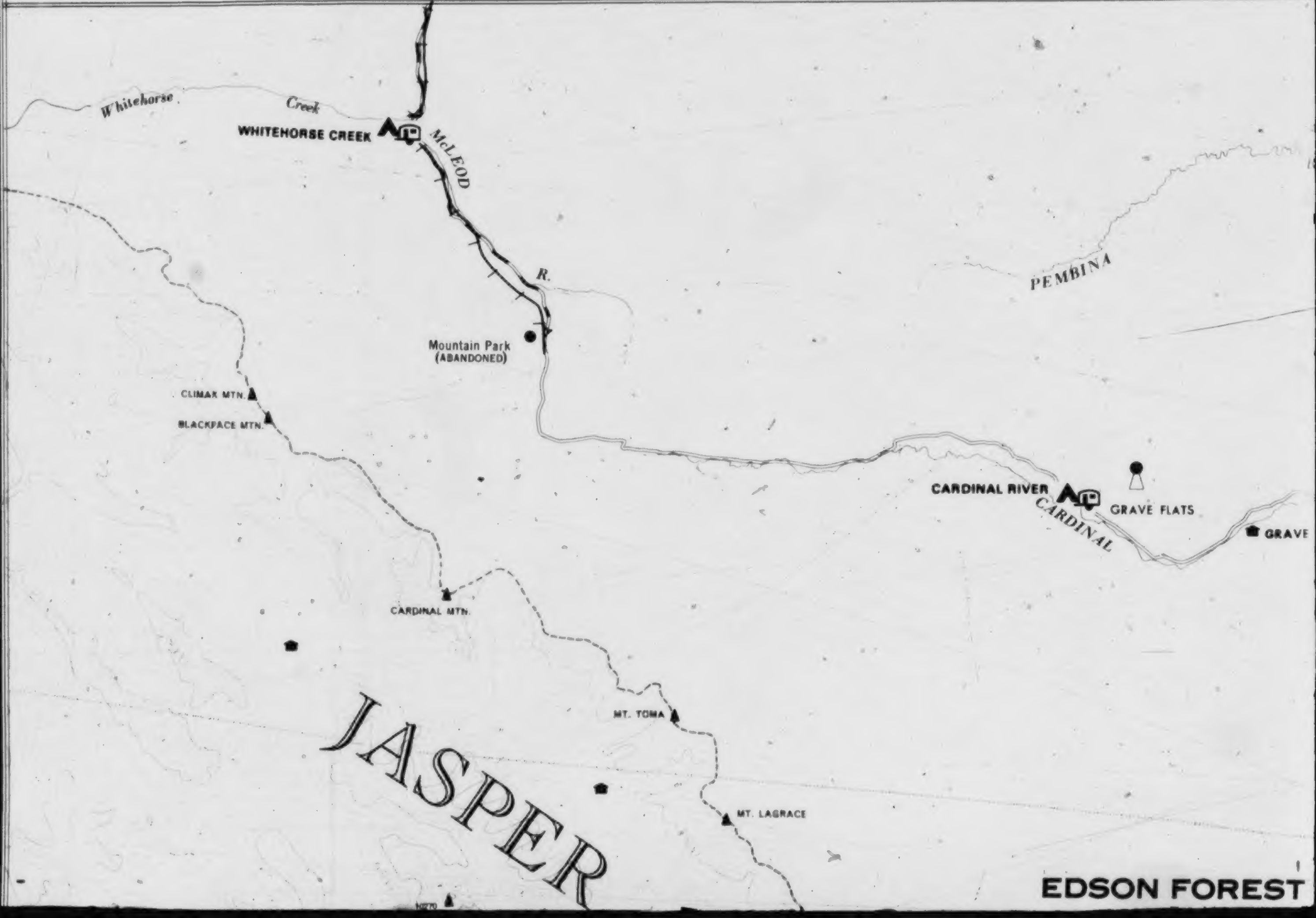
A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF Master of Science

Department of Geography

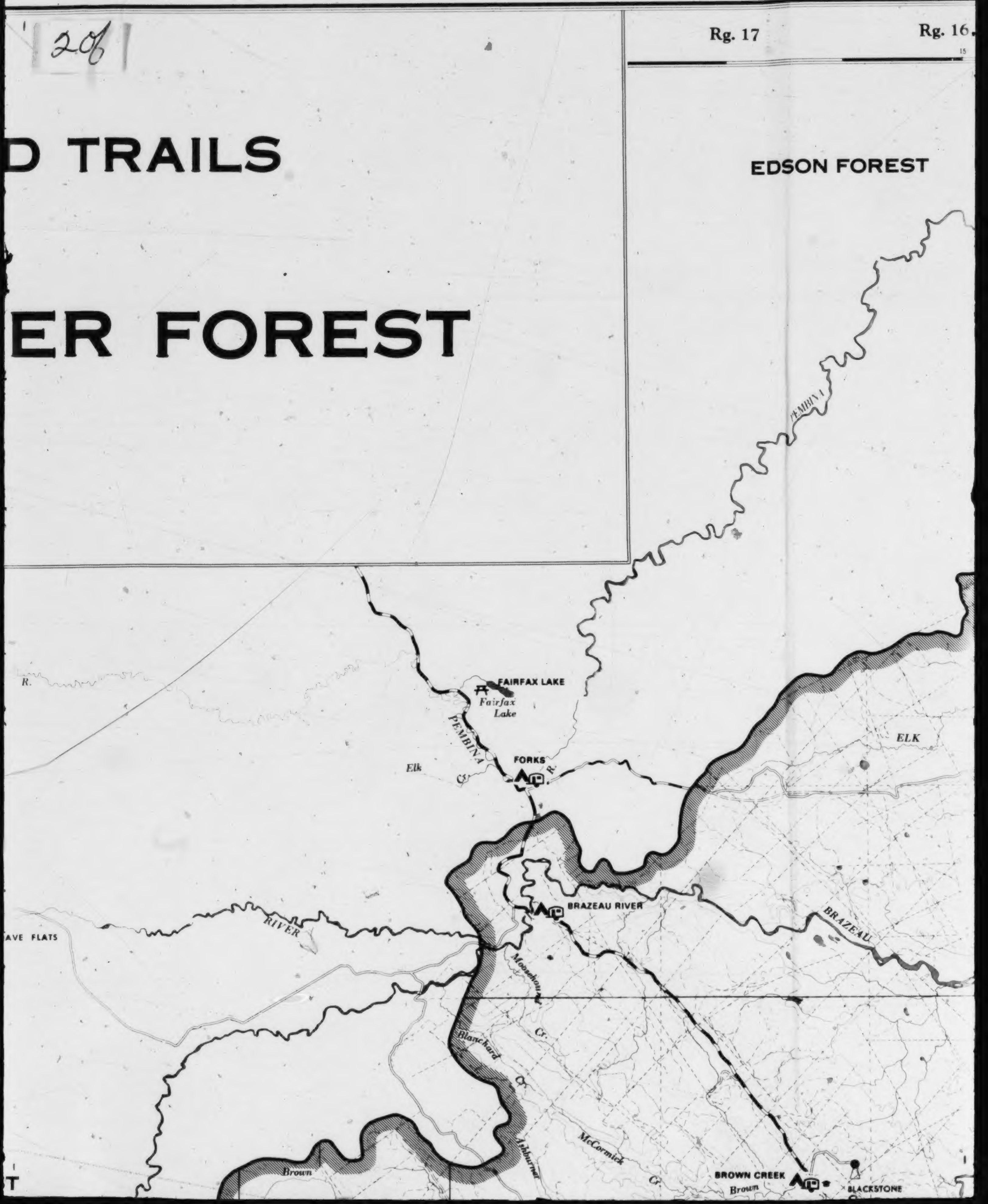
EDMONTON, ALBERTA
Fall, 1985

1 of

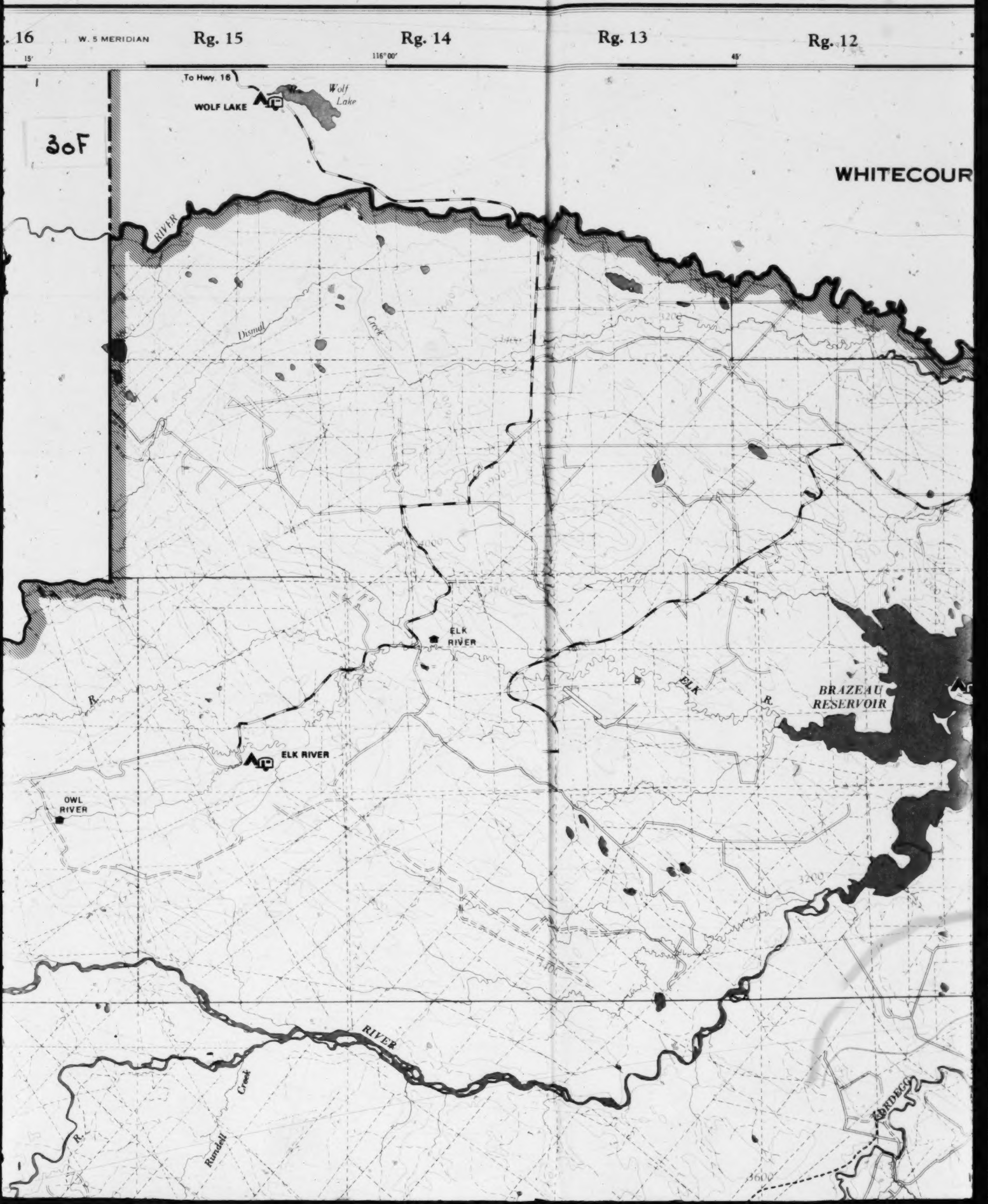
RECREATION AREAS AND
IN THE
ROCKY-CLEARWATE
ALBERTA FOREST SERVICE


Whitehorse
Creek
WHITEHORSE CREEK
McLEOD
R.
PEMBINA
Mountain Park
(ABANDONED)
CLIMAX MTN.
BLACKFACE MTN.
CARDINAL RIVER
CARDINAL
GRAVE FLATS
GRAVE
CARDINAL MTN.
MT. TOMA
MT. LAGRACE
JASPER
EDSON FOREST

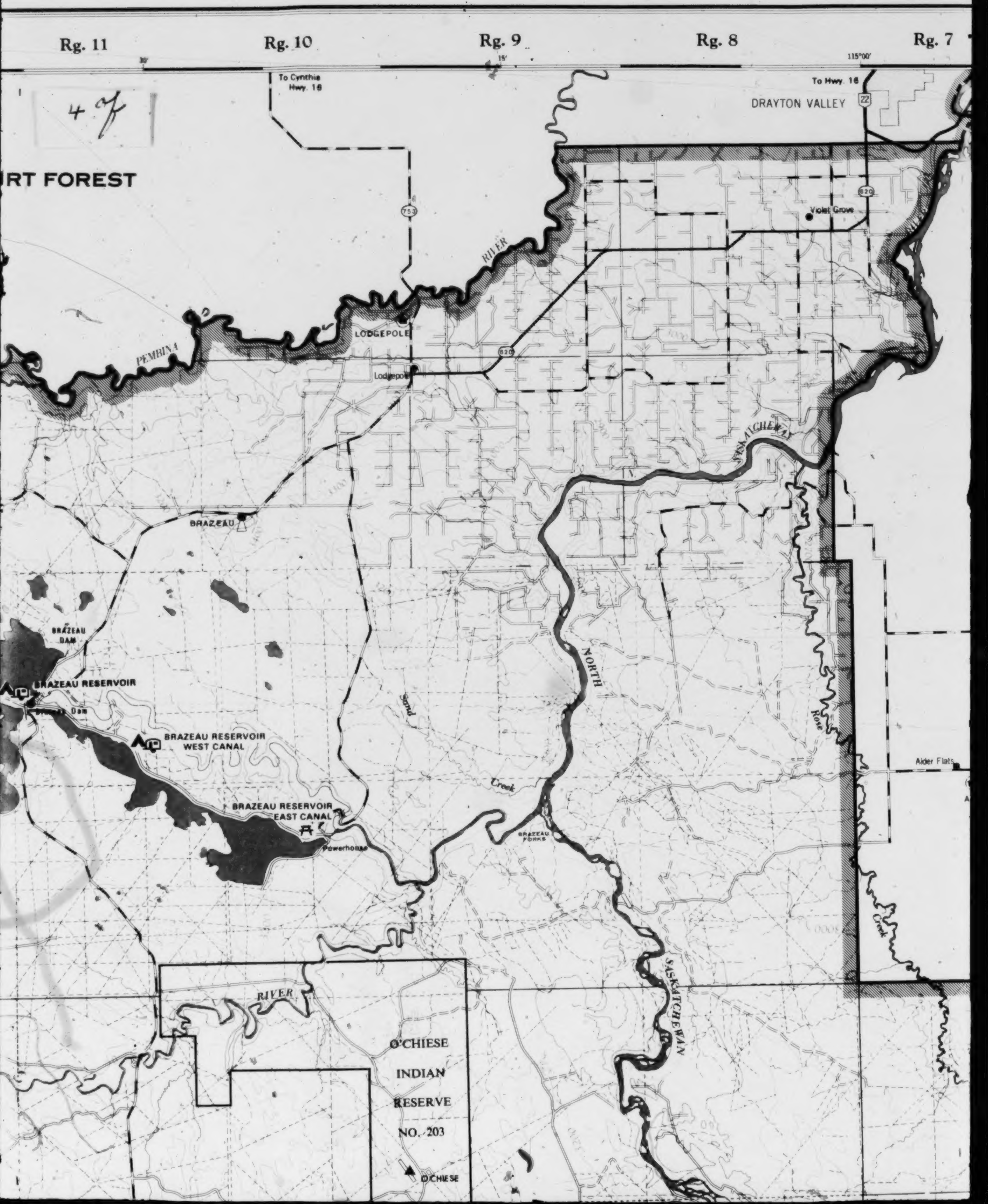
2 of


D TRAILS
ER FOREST
Rg. 17
Rg. 16
15
EDSON FOREST
PEMBINA
R.
FAIRFAX LAKE
Fairfax Lake
PEMBINA
FORKS
Elk
Cr.
R.
ELK
BRAZEAU RIVER
RIVER
AVE FLATS
BRAZEAU
Moosehound
Cr.
Blanchard
Cr.
Ashburner
McCormick
Cr.
Brown
BROWN CREEK
Brown
BLACKSTONE
T

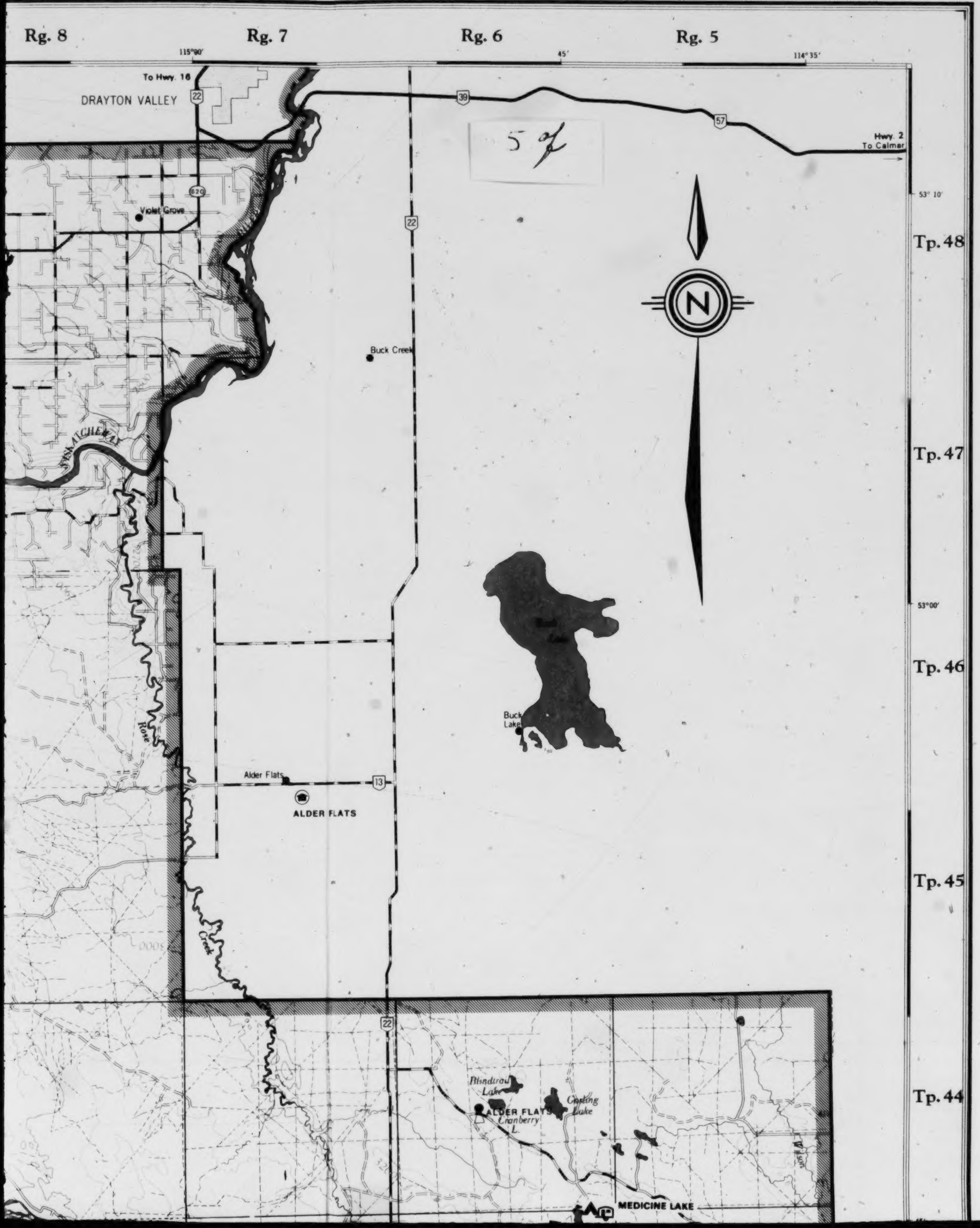
30F


. 16
W. 5 MERIDIAN
Rg. 15
Rg. 14
Rg. 13
Rg. 12
15'
116°00'
45'
To Hwy. 16
WOLF LAKE
Wolf Lake
WHITECOUR
RIVER
Dismal
Creek
3200
3400
3600
3900
4000
ELK RIVER
ELK R.
BRAZEAU RESERVOIR
R.
ELK RIVER
OWL RIVER
RIVER
Rundell Creek
R.
3200
3600

4 of


Rg. 11
Rg. 10
Rg. 9
Rg. 8
Rg. 7
30'
15'
115°00'
To Cynthia Hwy. 16
To Hwy. 16
DRAYTON VALLEY
22
RT FOREST
753
620
Violet Grove
RIVER
PEMBINA
LODGEPOLE
Lodgepole
SASKATCHEWAN
BRAZEAU
BRAZEAU DAM
BRAZEAU RESERVOIR
Dam
BRAZEAU RESERVOIR WEST CANAL
BRAZEAU RESERVOIR EAST CANAL
Powerhouse
Sand
Creek
NORTH
BRAZEAU FORKS
Rose
Creek
Alder Flats
RIVER
SASKATCHEWAN
O'CHIESE INDIAN RESERVE NO. 203
O'CHIESE

5 of


Rg. 8
Rg. 7
Rg. 6
Rg. 5
115°90'
45'
114°35'
To Hwy. 16
DRAYTON VALLEY
22
39
57
Hwy. 2
To Calmar
620
Violet Grove
53° 10'
Tp. 48
N
Buck Creek
SASKATCHEWAN
Tp. 47
53°00'
Tp. 46
Buck Lake
Rose
Alder Flats
13
ALDER FLATS
Tp. 45
Creek
22
Tp. 44
Blindtrail Lake
ALDER FLATS
Cranberry L.
Gosling Lake
Wilson
MEDICINE LAKE

6 oF

THE ROCKY/CLEARWATER FOREST IS A DIVERSE LANDSCAPE WITH AN ABUNDANCE OF NATURAL RESOURCES LOCATED IN THE "EASTERN SLOPES" OF THE ROCKY MOUNTAINS. IT IS MANAGED BY THE ALBERTA FOREST SERVICE UTILIZING THE MULTIPLE USE CONCEPT ALLOWING FOR NOT ONLY RECREATION BUT ALSO SUCH ACTIVITIES AS TIMBER HARVESTING, OIL AND GAS DEVELOPMENT, GRAZING AND OTHER NUMEROUS RESOURCE USES.

A LARGE NUMBER OF VISITORS COME TO THE ROCKY/CLEARWATER TO ENJOY THE FOREST ENVIRONMENT AND CAMP IN THE MANY FOREST RECREATION AREAS. A VAST NETWORK OF HISTORIC FOOT AND HORSE TRAILS (THE MAJORITY OF WHICH ARE UNMAINTAINED) INVITES HIKERS AND RIDERS TO VENTURE FAR FROM THE ROADSIDE TO EXPERIENCE THE PLEASURE OF BACKCOUNTRY LIFE.

THE ROCKY/CLEARWATER FOREST IS MANAGED FOR **YOU**. AS A FOREST VISITOR, YOU HAVE A KEY ROLE IN PROTECTING THIS BEAUTIFUL AREA FOR FUTURE GENERATIONS.

PLEASE
- ADHERE TO THE "PACK IN, PACK OUT" POLICY FOR YOUR GARBAGE WHILE NOT STAYING IN A DEVELOPED RECREATION AREA.
- BE EXTREMELY CAREFUL WITH OPEN FIRES. THE USE OF SELF-CONTAINED STOVES IS RECOMMENDED.
- FISHING AND HUNTING ARE ALLOWED IN THE ROCKY/CLEARWATER FOREST SUBJECT TO ALBERTA BIG GAME AND SPORT FISHING REGULATIONS.
- WHILE VISITING A FOREST SERVICE RECREATION AREA COMPLY WITH ALL POSTED SIGNS AND REGULATIONS.
- REMEMBER THAT ALL **BEARS ARE DANGEROUS**, THEREFORE, TAKE THE NECESSARY PRECAUTIONS.

FOR ADDITIONAL INFORMATION CONTACT

ALBERTA FOREST SERVICE
ROCKY/CLEARWATER FOREST
BOX 1720, ROCKY MTN. HOUSE
ALBERTA, CANADA, T0M 1T0
PHONE 845-3394

or

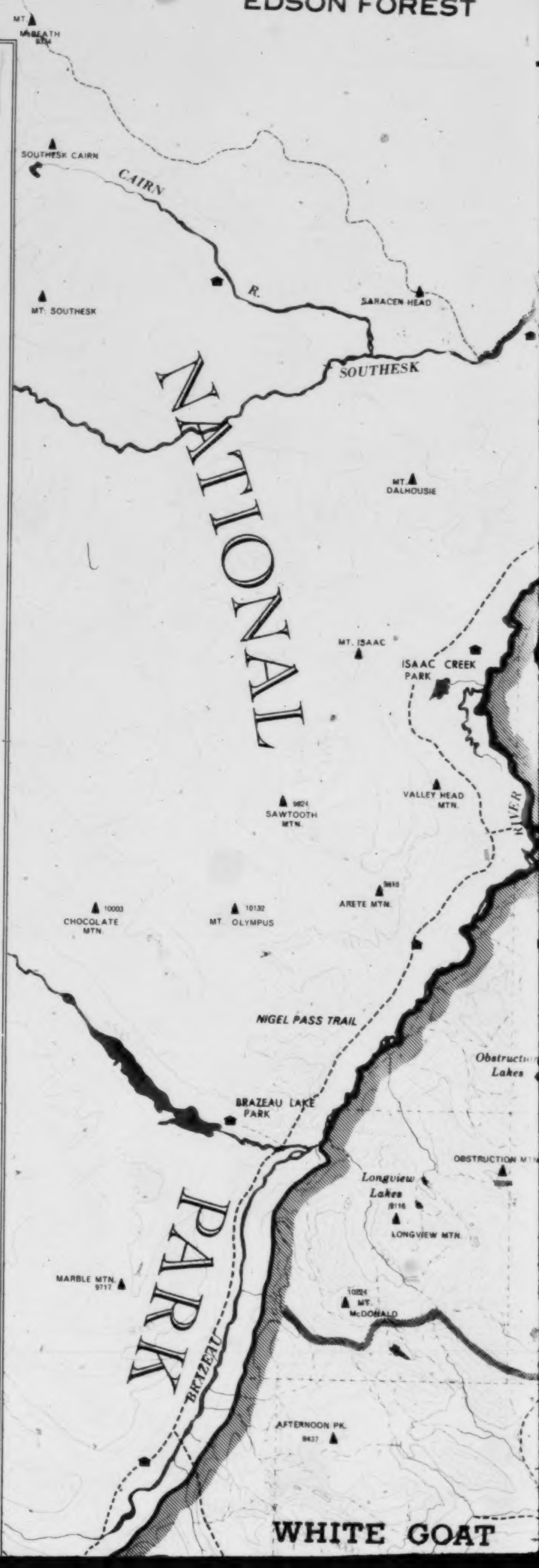
ALBERTA FOREST SERVICE
6th FLOOR, BRAMALEA BUILDING
9920-108 STREET, EDMONTON
ALBERTA, CANADA, T5K 2M4
PHONE 427-3582

TOPOGRAPHIC MAPS (APPROXIMATE SCALE 1:50 000) OF ROCKY/CLEARWATER FOREST ARE AVAILABLE, FOR A NOMINAL FEE, AT THE FOREST HEADQUARTERS OR FROM:

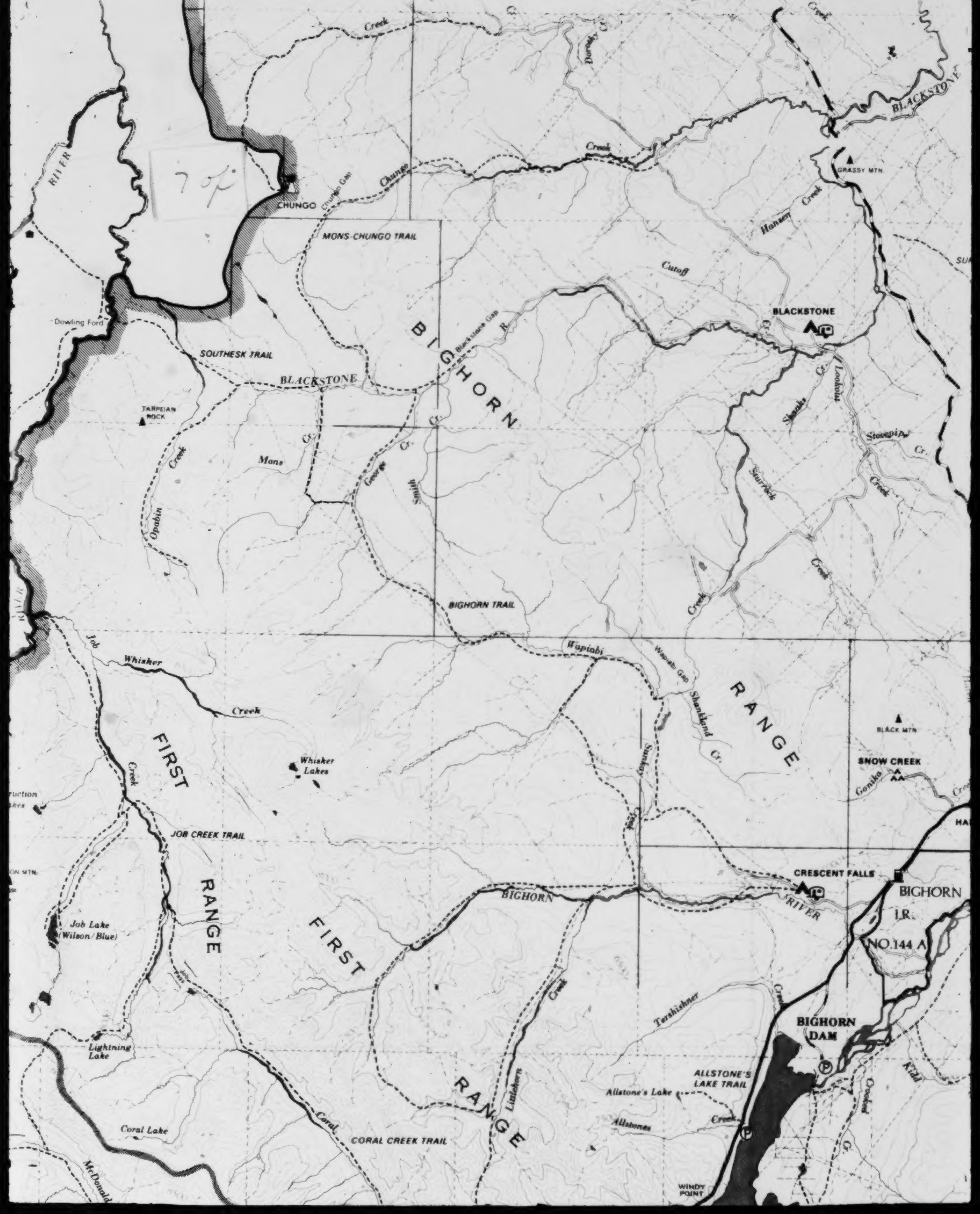
MAP DATA CENTRE
2nd FLOOR, NORTH TOWER, PETROLEUM PLAZA
9945-108 STR., EDMONTON
ALBERTA, CANADA, T5K 2G6
PHONE 427-3520

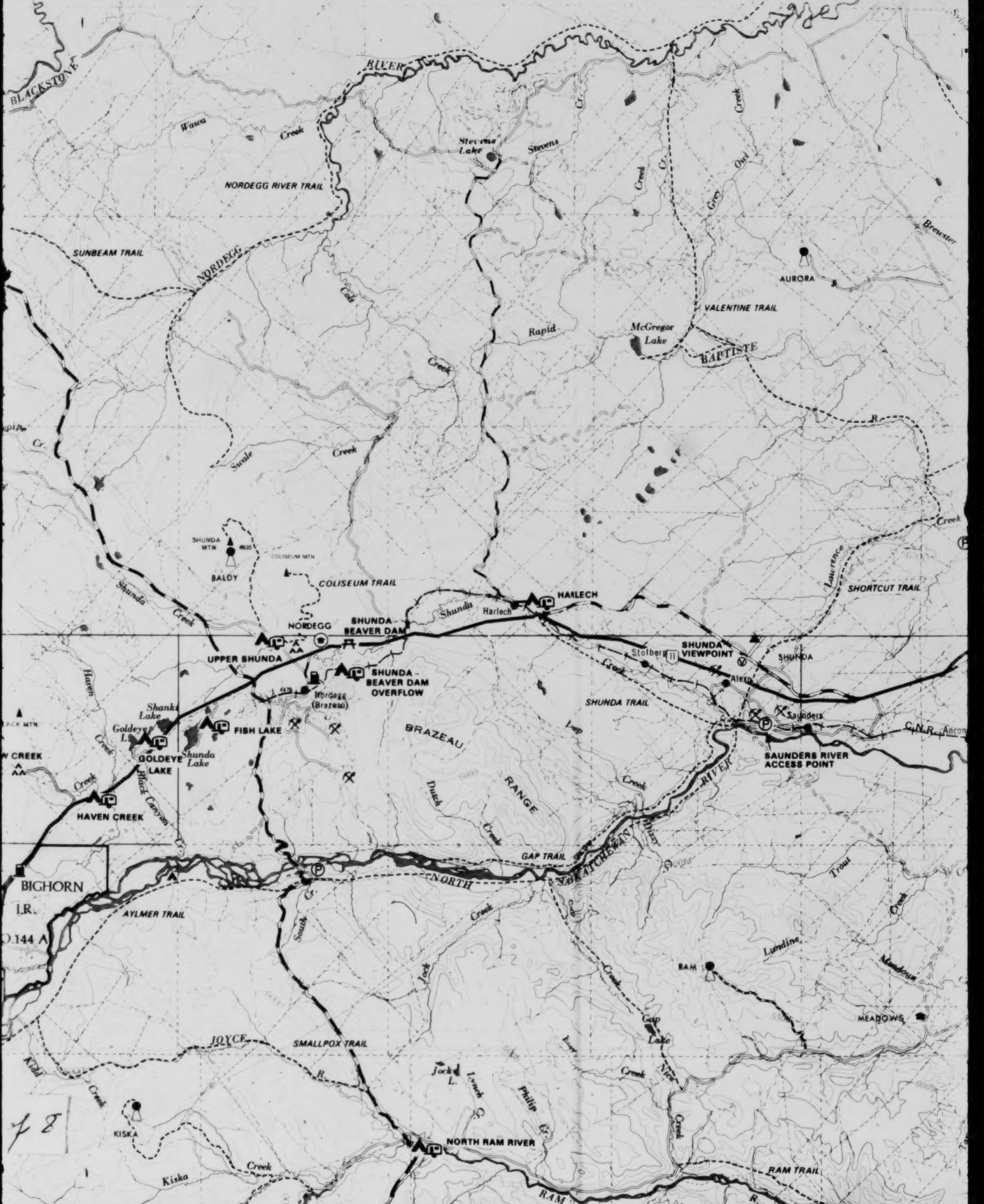
LEGEND

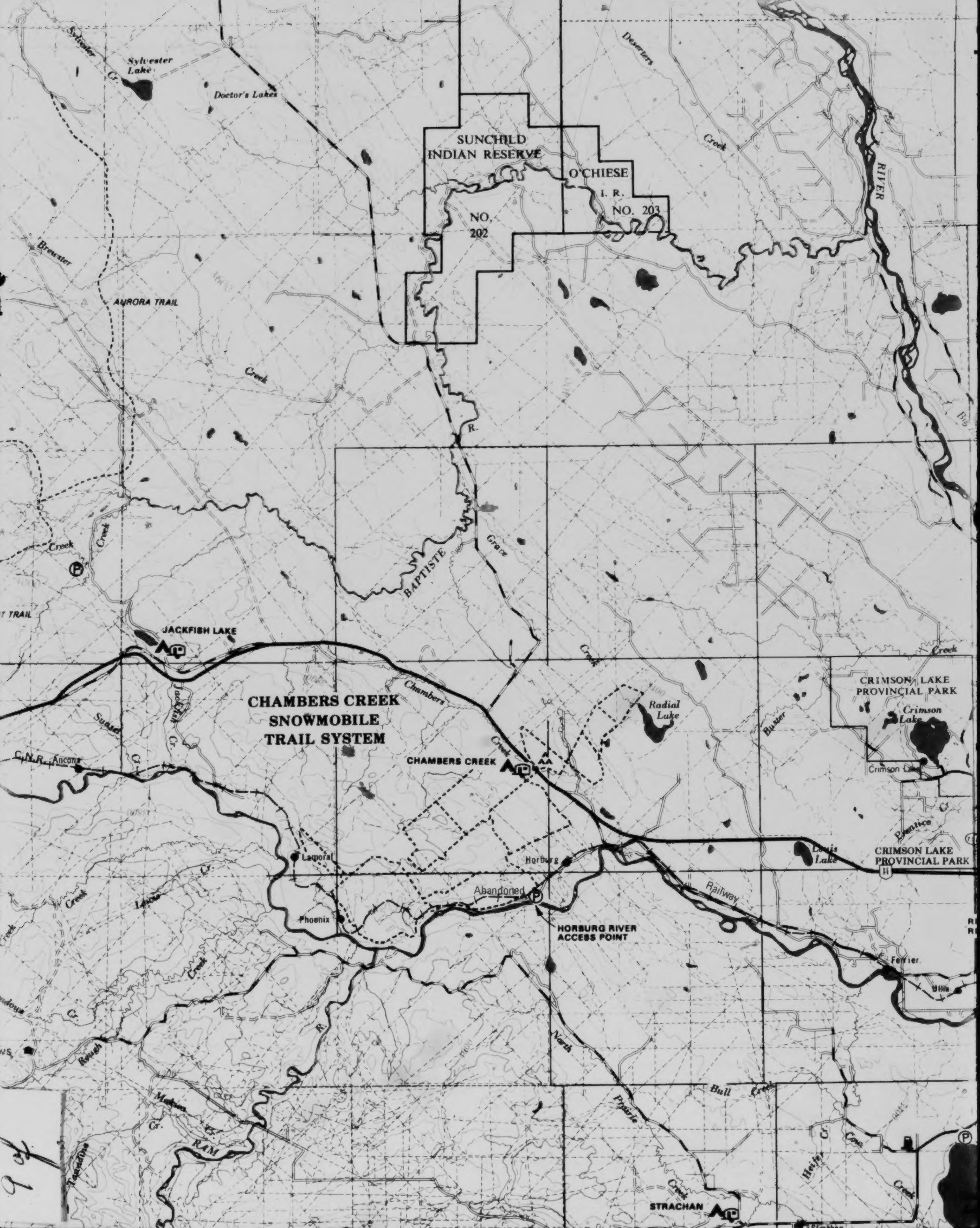
Recreation Area - Camping	▲
Recreation Area - Day Use Only	⊼
Group Camp	▲▲▲
Developed Backcountry Campsite	▲
Parking Area/Staging Area	Ⓟ
Recreation Trail	- - - - - -
Service Centre	■
Highways, Paved - Gravelled	━━ 11 ══
Forestry Trunk Road	━ ━ ━
All Weather Road, Gravelled	═ ━ ═
Dry Weather Road, Dirt	═══
Truck Trail	= = = =
Seismograph Line or Trail	- - - - - -
Railways	┼┼┼ C.N.R.
Bridge, Overpass, Underpass	━━
Mountain Pass	Howse Pass //
Airstrip	▭
Town	✚
Village, Hamlet, Post Office, Locality	●
Provincial Park	▢
Intermittent Stream	~ - ~ -
River	～
Braided Stream	～
Falls	～
Dam	～
Glacier	
Township Boundary, Surveyed	──

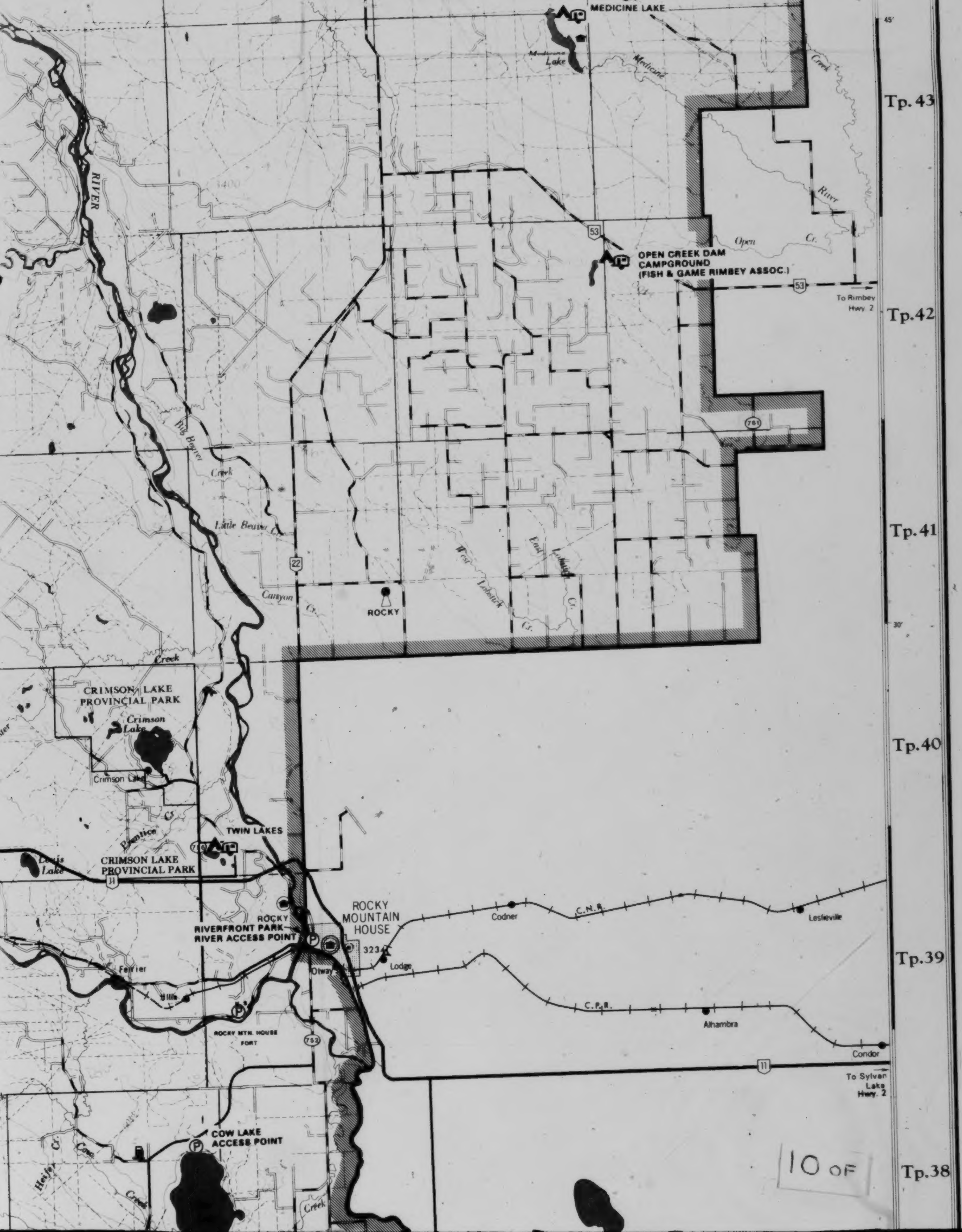

10270 MT. BALINHARD
EDSON FOREST
MT. McBEATH 9394
SOUTHESK CAIRN
CAIRN
R.
SARACEN HEAD
MT. SOUTHESK
SOUTHESK
NATIONAL
PARK
MT. DALHOUSIE
MT. ISAAC
ISAAC CREEK PARK
VALLEY HEAD MTN.
RIVER
9824 SAWTOOTH MTN.
ARETE MTN.
10003 CHOCOLATE MTN.
10132 MT. OLYMPUS
NIGEL PASS TRAIL
Obstruction Lakes
BRAZEAU LAKE PARK
OBSTRUCTION MTN.
Longview Lakes
9116
LONGVIEW MTN.
MARBLE MTN. 9717
10224 MT. McDONALD
BRAZEAU
AFTERNOON PK. 9437
WHITE GOAT

7 of


CHUNGO
Chungo Gap
Chungo
Creek
Creek
Cr.
MONS-CHUNGO TRAIL
BLACKSTONE
GRASSY MTN
Hansen Creek
Cutoff
BLACKSTONE
RIVER
Dowling Ford
SOUTHESK TRAIL
BLACKSTONE
Blackstone Gap
TARPEIAN ROCK
BIGHORN
Mons
Cr.
Opabin Creek
George Cr.
Smith
Shanks Cr.
Lookout
Stovepipe Cr.
Creek
Sturrock
Creek
Creek
BIGHORN TRAIL
Wapiabi
Wapiabi Gap
Shankland Cr.
RANGE
Job
Whisker
Creek
Creek
FIRST
RANGE
Whisker Lakes
BLACK MTN
SNOW CREEK
Goniko
JOB CREEK TRAIL
CRESCENT FALLS
BIGHORN
RIVER
BIGHORN
I.R.
NO.144 A
Job Lake (Wilson/Blue)
FIRST
RANGE
Littlehorn
Creek
Tershishner
BIGHORN DAM
Lightning Lake
ALLSTONE'S LAKE TRAIL
Allstone's Lake
Allstones
Creek
Coral Lake
Coral
CORAL CREEK TRAIL
McDonald
WINDY POINT
Crooked
Kidd
Cr.


BLACKSTONE
RIVER
Wawa Creek
NORDEGG RIVER TRAIL
Stevens Lake
Stevens Cr.
Creek
Cr.
Grey Owl Creek
Brewster
SUNBEAM TRAIL
NORDEGG
Cole
AURORA
VALENTINE TRAIL
Rapid
McGregor Lake
BAPTISTE
Creek
R.
Swale Creek
Cr.
Creek
SHUNDA MTN
COLISEUM MTN
BALDY
COLISEUM TRAIL
Laurence
SHORTCUT TRAIL
HARLECH
Harlech
Shunda
Shunda Creek
NORDEGG
SHUNDA - BEAVER DAM
UPPER SHUNDA
SHUNDA - BEAVER DAM OVERFLOW
Nordegg (Brazeau)
Stolberg
SHUNDA VIEWPOINT
SHUNDA
Alexo
Creek
SHUNDA TRAIL
Saunders
C.N.R.
Ancona
Haven Creek
Shanks Lake
Goldeye L.
FISH LAKE
BLACK MTN.
CREEK
GOLDEYE LAKE
Shunda Lake
BRAZEAU RANGE
Lap Creek
RIVER
SAUNDERS RIVER ACCESS POINT
Dutch Creek
Black Canyon
HAVEN CREEK
Creek
BIGHORN I.R. NO.144 A
GAP TRAIL
SASKATCHEWAN
NORTH
Trout Creek
AYLMER TRAIL
South Cr.
Creek
Jock
Lundine
RAM
Meadows Creek
Creek
Gap Lake
MEADOWS
JOYCE
SMALLPOX TRAIL
R.
Jock L.
Lynch Cr.
Philip Cr.
Creek
Nice Creek
Kidd Creek
KISKA
NORTH RAM RIVER
Kiska Creek
RAM TRAIL
RAM
R.
FORKS
78


Sylvester Cr.
Sylvester Lake
Doctor's Lakes
Deserters Creek
SUNCHILD INDIAN RESERVE NO. 202
O'CHIESE I. R. NO. 203
RIVER
Brewster
AURORA TRAIL
Creek
BAPTISTE R.
Grace
Creek
Creek
TRAIL
JACKFISH LAKE
Jackfish Cr.
Chambers
CHAMBERS CREEK SNOWMOBILE TRAIL SYSTEM
Sunset Cr.
C.N.R. Ancona
Radial Lake
Buster
Creek
CRIMSON LAKE PROVINCIAL PARK
Crimson Lake
Crimson Lake
Prentice Cr.
CRIMSON LAKE PROVINCIAL PARK
Chambers Creek
CHAMBERS CREEK
Lasoral
Horburg
Louis Lake
Railway
Abandoned
Phoenix
HORBURG RIVER ACCESS POINT
Creek
Lynx Cr.
Creek
Cr.
R.
Ferrier
North Prairie Creek
Rough
Bull Creek
Heifer Cr.
Cow Creek
Matson Cr.
RAM
STRACHAN
Strachan


MEDICINE LAKE
Medicine Lake
Medicine
Creek
RIVER
River
Open Cr.
53
OPEN CREEK DAM
CAMPGROUND
(FISH & GAME RIMBEY ASSOC.)
To Rimbey Hwy 2
761
Big Beaver Creek
Little Beaver Cr.
22
Canyon Cr.
ROCKY
West Lobstick Cr.
East Lobstick Cr.
Creek
CRIMSON LAKE PROVINCIAL PARK
Crimson Lake
Crimson Lake
Prentice Cr.
TWIN LAKES
Louis Lake
CRIMSON LAKE PROVINCIAL PARK
11
ROCKY
RIVERFRONT PARK
RIVER ACCESS POINT
ROCKY MOUNTAIN HOUSE
3234
Lodge
Otway
Ferrier
Bills
ROCKY MTN. HOUSE FORT
752
Codner
C.N.R.
Leslieville
C.P.R.
Alhambra
Condor
11
To Sylvan Lake Hwy. 2
COW LAKE ACCESS POINT
Cow Creek
Heifer Cr.
Creek
45'
30'
Tp. 43
Tp. 42
Tp. 41
Tp. 40
Tp. 39
Tp. 38

10 OF

Township Boundary, Surveyed	
Township Boundary, Unsurveyed	
Forest Boundary	▨
Mountain Peaks	▲
Mines	⚒
Historical Site	*Frank Slide* H. S.
Microwave Tower	⊙
Ranger Cabin	☗
Ranger Station	◉
Lookout Tower	▲
Contour Intervals in Feet	

11 of

True North
22° 51'
Magnetic North

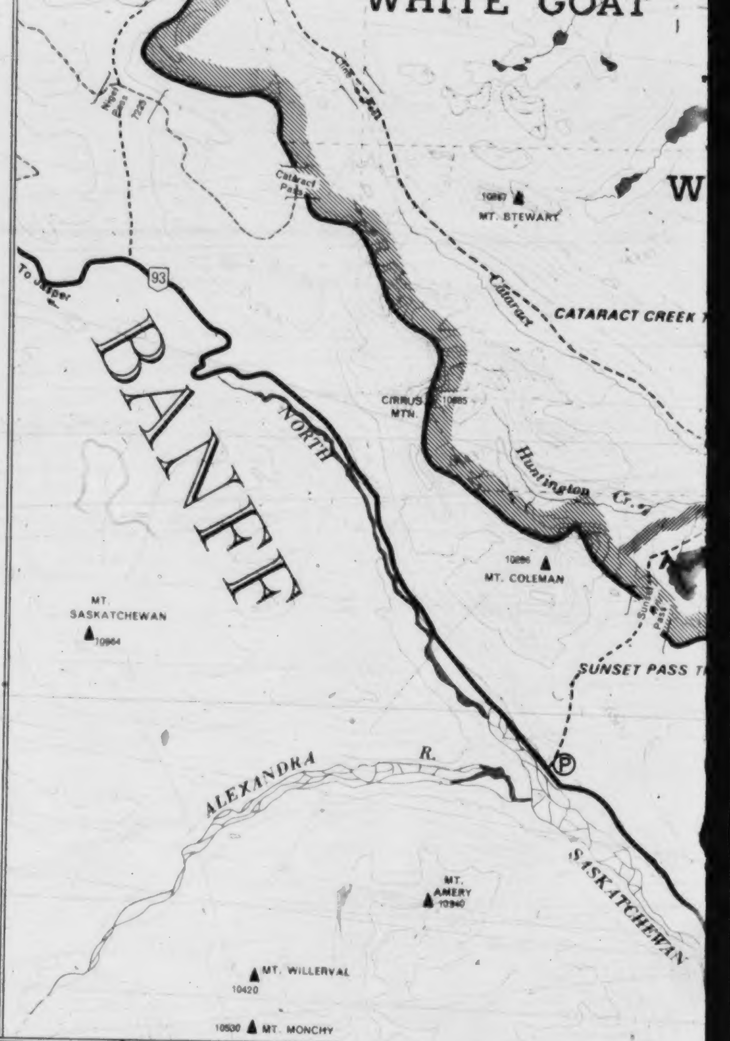
Approximate Magnetic Declination
1973

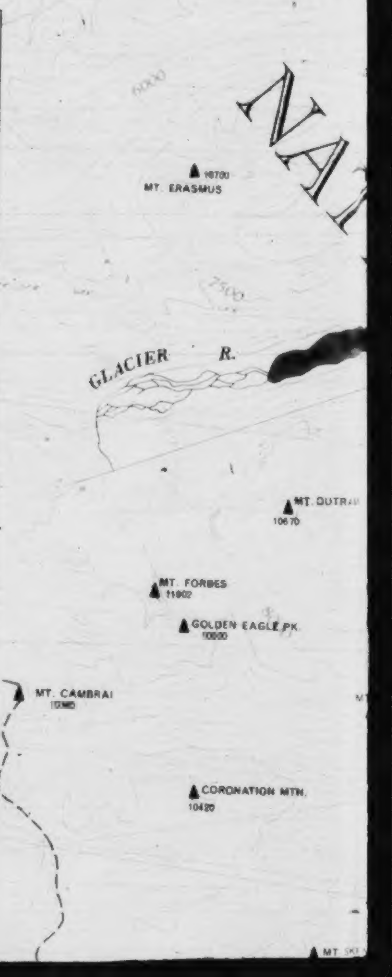
The Average Declination Taken at The Centre of the Map, Approximate Centse of Tp 40, Rg.15, W.5 Meridian is 22 51' East, With An Annual Decrease of 3' West.

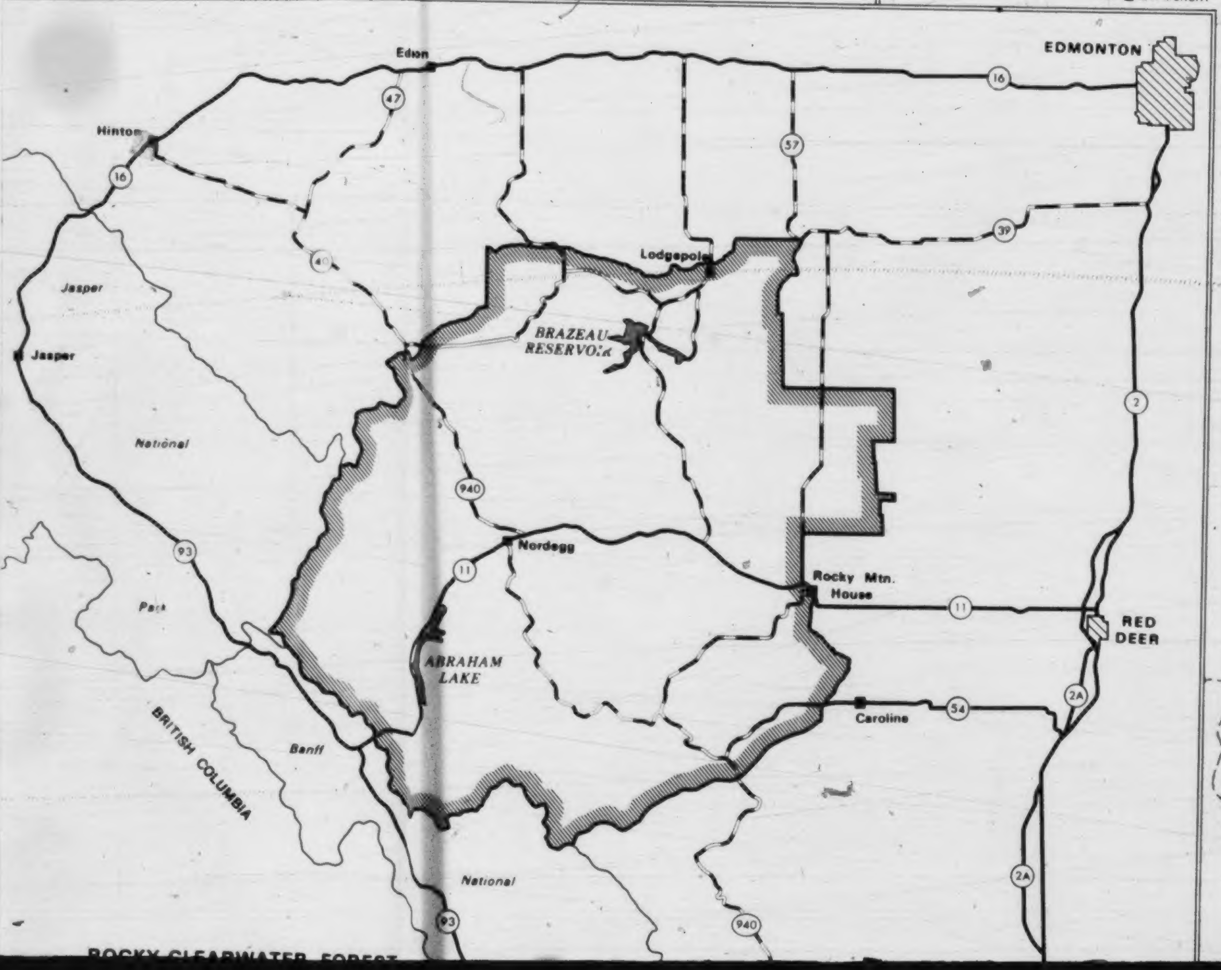
Universal Transverse Mercator Projection

Scale: One Inch Equals Three Miles

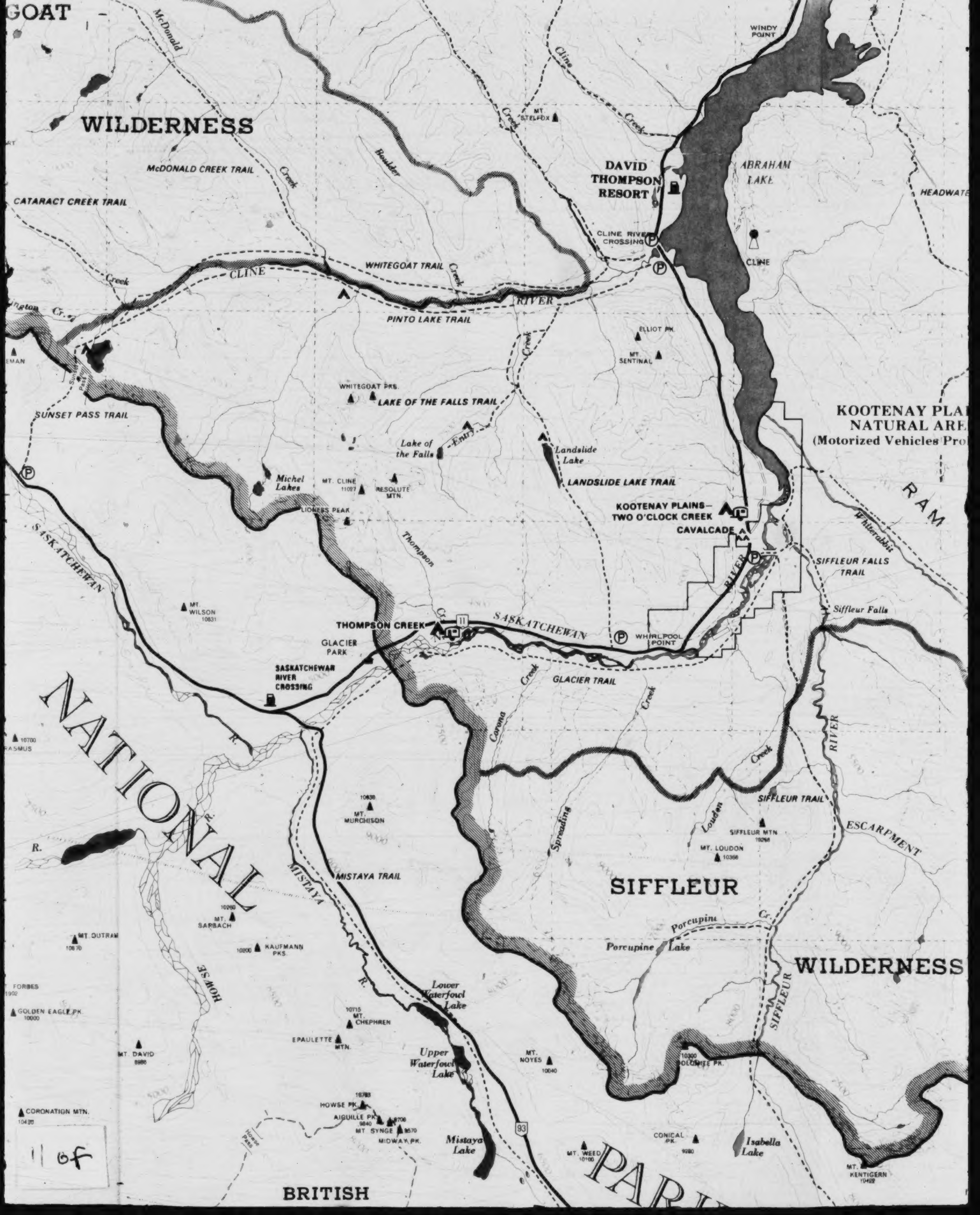
6
5
4
3
2
1
0
3
6
Miles


WHITE GOAT
W
MT. STEWART
CATARACT CREEK T
Cataract Pass
Cataract
To Jasper
93
BANFF
NORTH
CIRRUS MTN.
Huntington Cr.
MT. COLEMAN
MT. SASKATCHEWAN
SUNSET PASS T
ALEXANDRA R.
SASKATCHEWAN
MT. AMERY
MT. WILLERVAL
MT. MONCHY

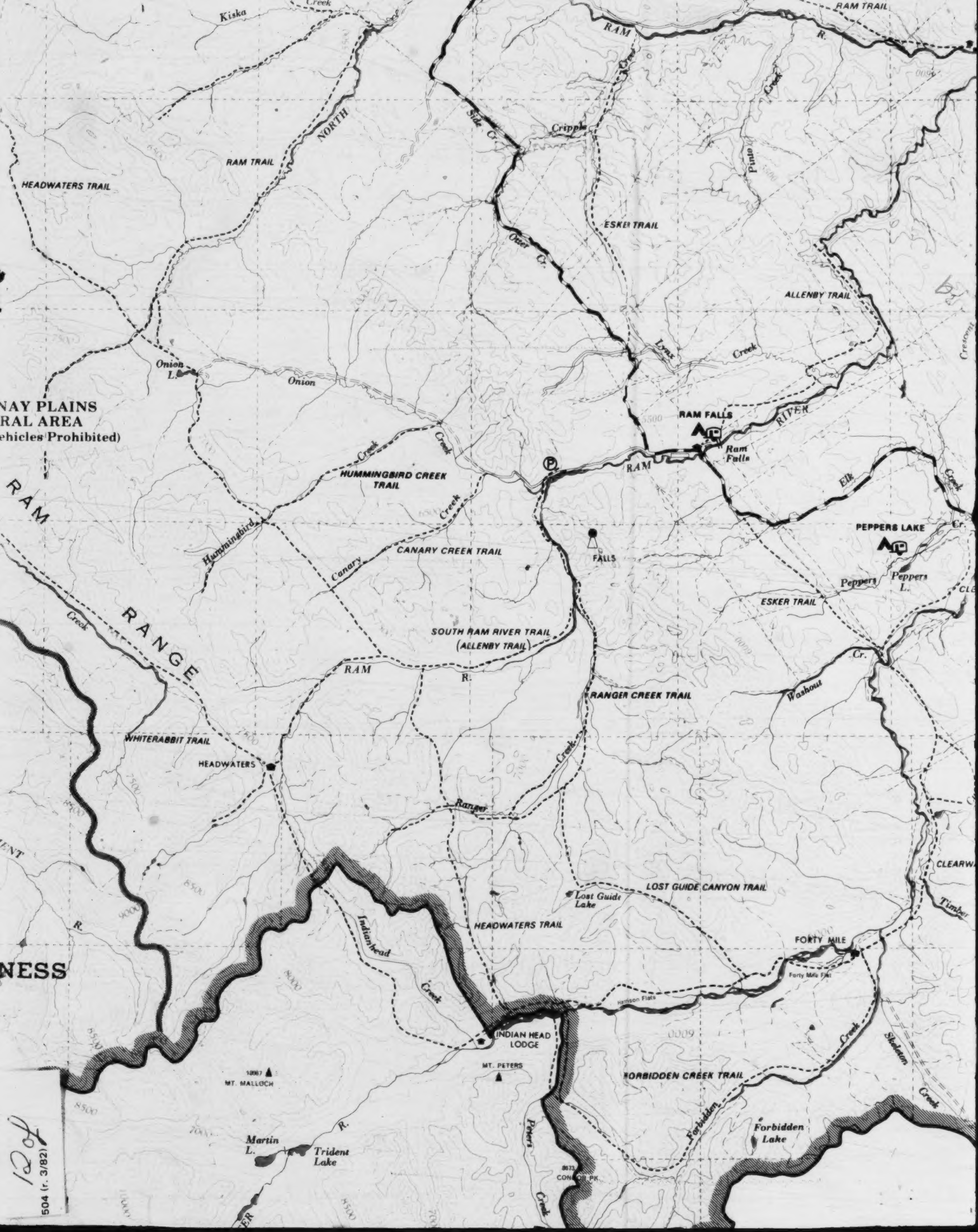

NA
MT. ERASMUS
GLACIER R.
MT. OUTRAM
MT. FORBES
GOLDEN EAGLE PK.
MT. CAMBRAI
CORONATION MTN.


Edson
EDMONTON
Hinton
16
47
57
39
Lodgepole
40
Jasper
Jasper
BRAZEAU RESERVOIR
National
940
2
Nordegg
93
11
Rocky Mtn. House
11
Park
ABRAHAM LAKE
RED DEER
Caroline
54
2A
BRITISH COLUMBIA
Banff
National
93
940
2A

ROCKY CLEARWATER FOREST


GOAT
WILDERNESS
McDonald
McDONALD CREEK TRAIL
CATARACT CREEK TRAIL
Creek
Boulder
Cline
Creek
MT. STELFOX
Creek
WINDY POINT
DAVID THOMPSON RESORT
ABRAHAM LAKE
HEADWATE
CLINE RIVER CROSSING
CLINE
WHITEGOAT TRAIL
Creek
CLINE
RIVER
PINTO LAKE TRAIL
Cr.
ELLIOT PK.
MT. SENTINAL
Creek
WHITEGOAT PKS.
LAKE OF THE FALLS TRAIL
SUNSET PASS TRAIL
Sunset Pass
Lake of the Falls
Entry
Landslide Lake
LANDSLIDE LAKE TRAIL
KOOTENAY PLA
NATURAL ARE
(Motorized Vehicles Pro
Michel Lakes
MT. CLINE 11027
RESOLUTE MTN.
LIONESS PEAK
KOOTENAY PLAINS— TWO O'CLOCK CREEK
CAVALCADE
RAM
Whiterabbit
SASKATCHEWAN
Thompson
RIVER
SIFFLEUR FALLS TRAIL
Siffleur Falls
MT. WILSON 10631
Cr.
11
SASKATCHEWAN
THOMPSON CREEK
WHIRLPOOL POINT
GLACIER PARK
SASKATCHEWAN RIVER CROSSING
Creek
GLACIER TRAIL
Creek
NATIONAL
R.
10700
RASMUS
Corona
Creek
RIVER
SIFFLEUR TRAIL
10636 MT. MURCHISON
Spreading
Loudon
SIFFLEUR MTN 10298
MT. LOUDON 10366
ESCARPMENT
R.
R.
MISTAYA
MISTAYA TRAIL
SIFFLEUR
10260 MT. SARBACH
MT. OUTRAM 10670
10200 KAUFMANN PKS.
Porcupine Cr.
Porcupine Lake
WILDERNESS
HOWSE
R.
MT. FORBES 11902
GOLDEN EAGLE PK. 10000
Lower Waterfowl Lake
10715 MT. CHEPHREN
EPAULETTE MTN.
MT. DAVID 9986
Upper Waterfowl Lake
MT. NOYES 10040
10300 DOLOMITE PK.
SIFFLEUR
CORONATION MTN. 10420
10793 HOWSE PK.
AIGUILLE PK. 10700
9840 MT. SYNGE 9570
MIDWAY PK.
Howse Pass
93
Mistaya Lake
MT. WEED 10100
CONICAL PK. 9280
Isabella Lake
MT. KENTIGERN 10422
PARK
BRITISH

1| of


Kiska
Creek
RAM TRAIL
RAM
R.
NORTH
Side Cr.
Cripple
Creek
RAM TRAIL
HEADWATERS TRAIL
ESKER TRAIL
Otter Cr.
ALLENBY TRAIL
Crescent
Onion L.
Onion
Lynx
Creek
NAY PLAINS
RAL AREA
ehicles Prohibited)
RAM FALLS
RIVER
Ram Falls
Creek
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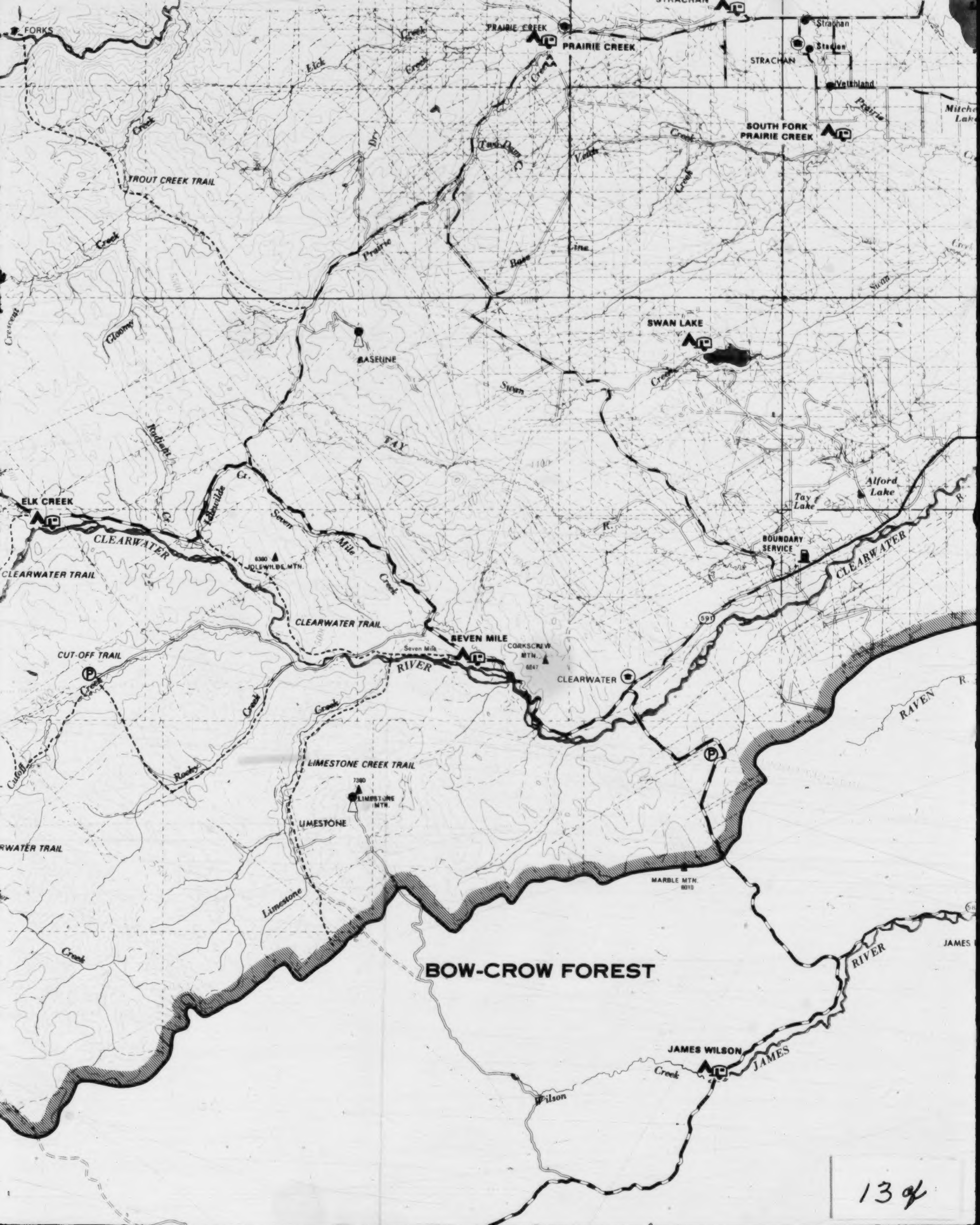
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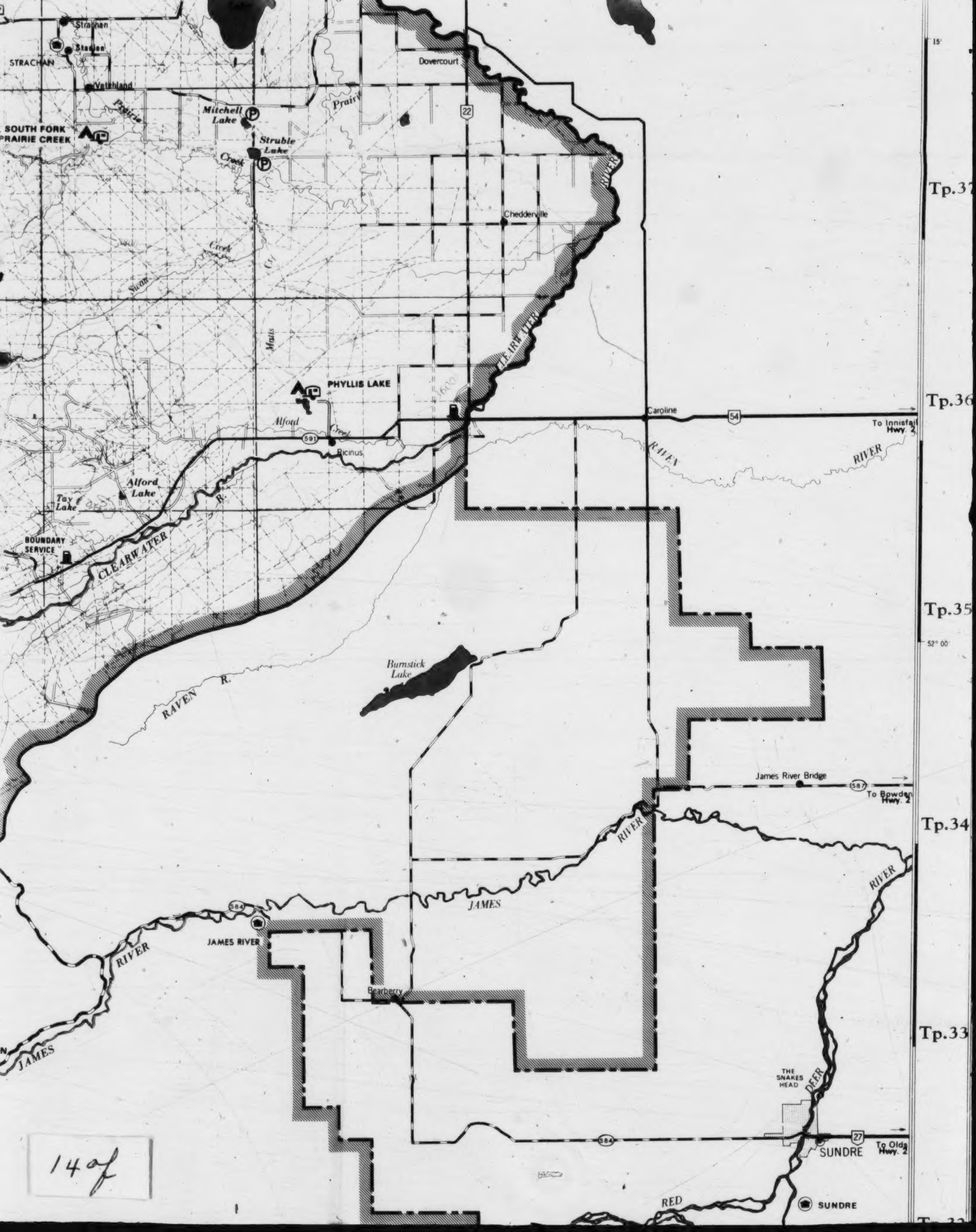
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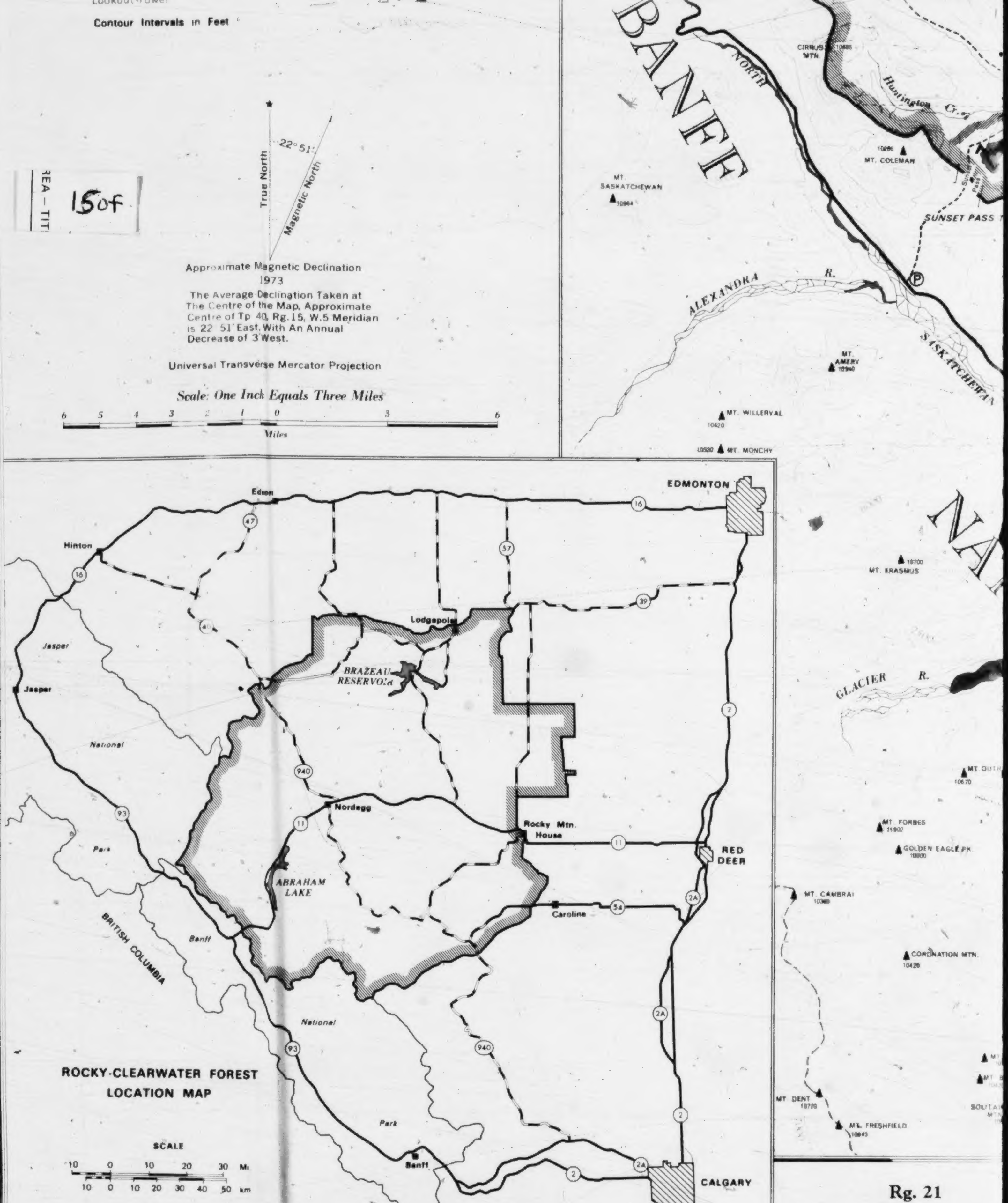

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Universal Transverse Mercator Projection

Scale: One Inch Equals Three Miles

ROCKY-CLEARWATER FOREST LOCATION MAP

True North
Magnetic North
22° 51′
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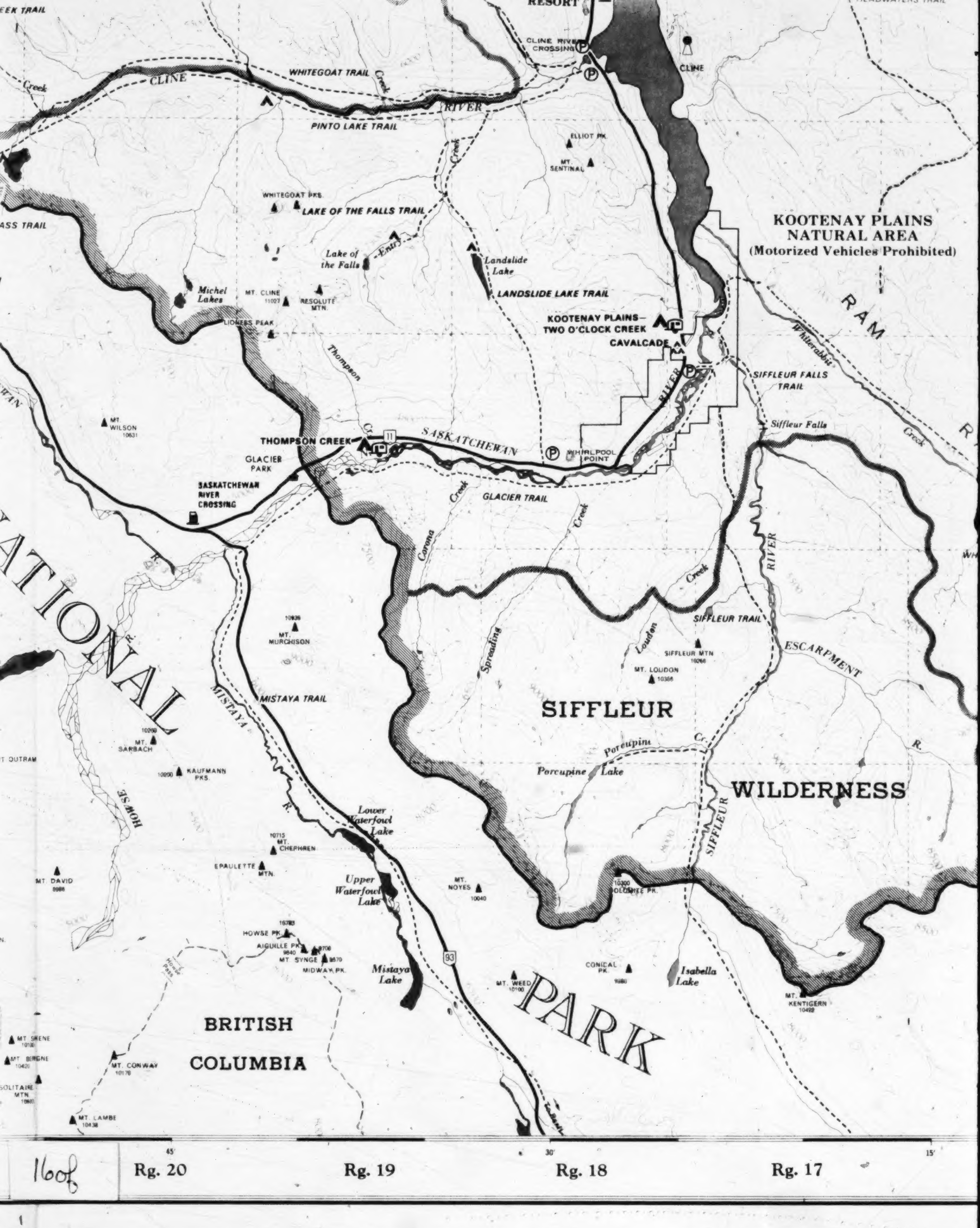

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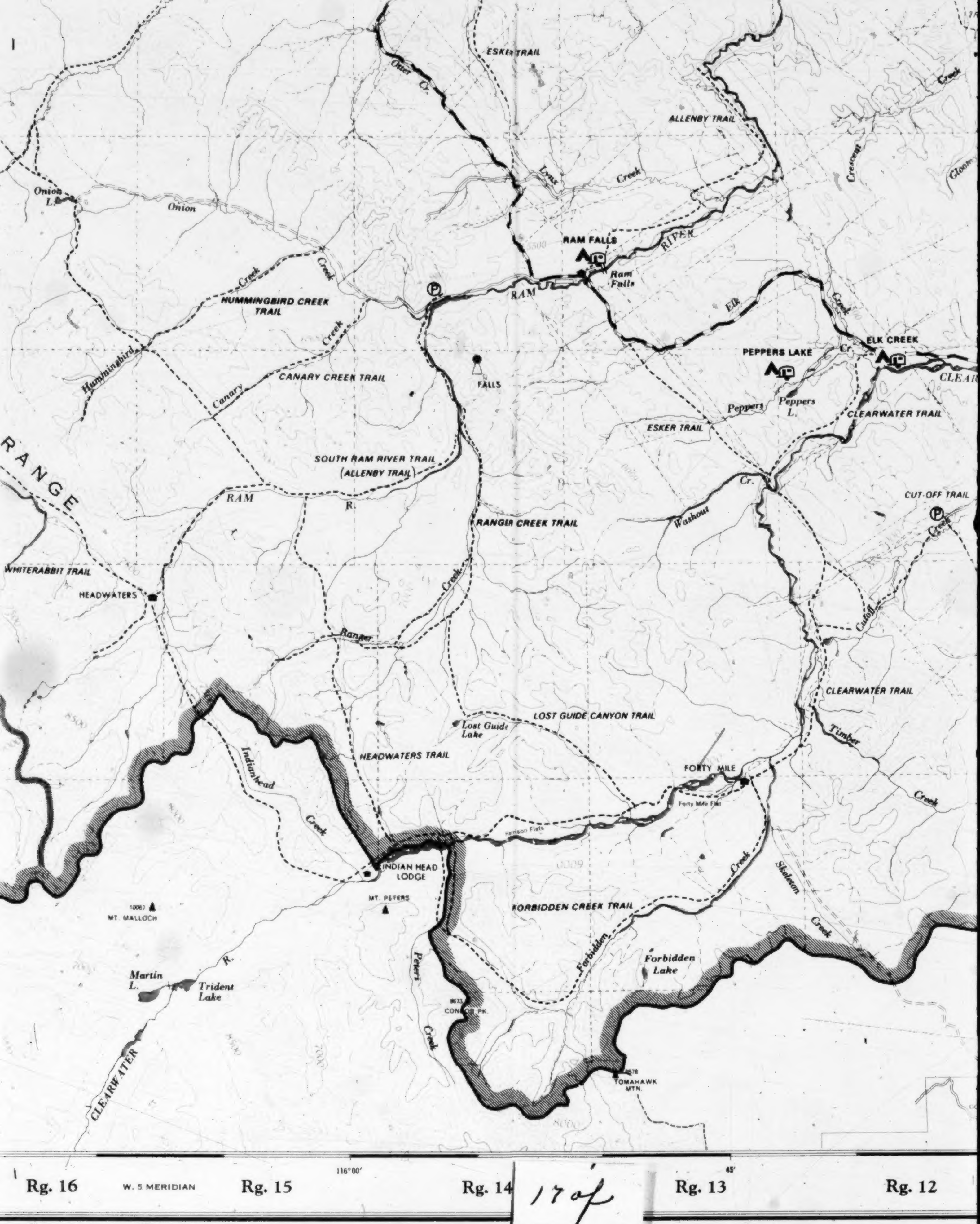
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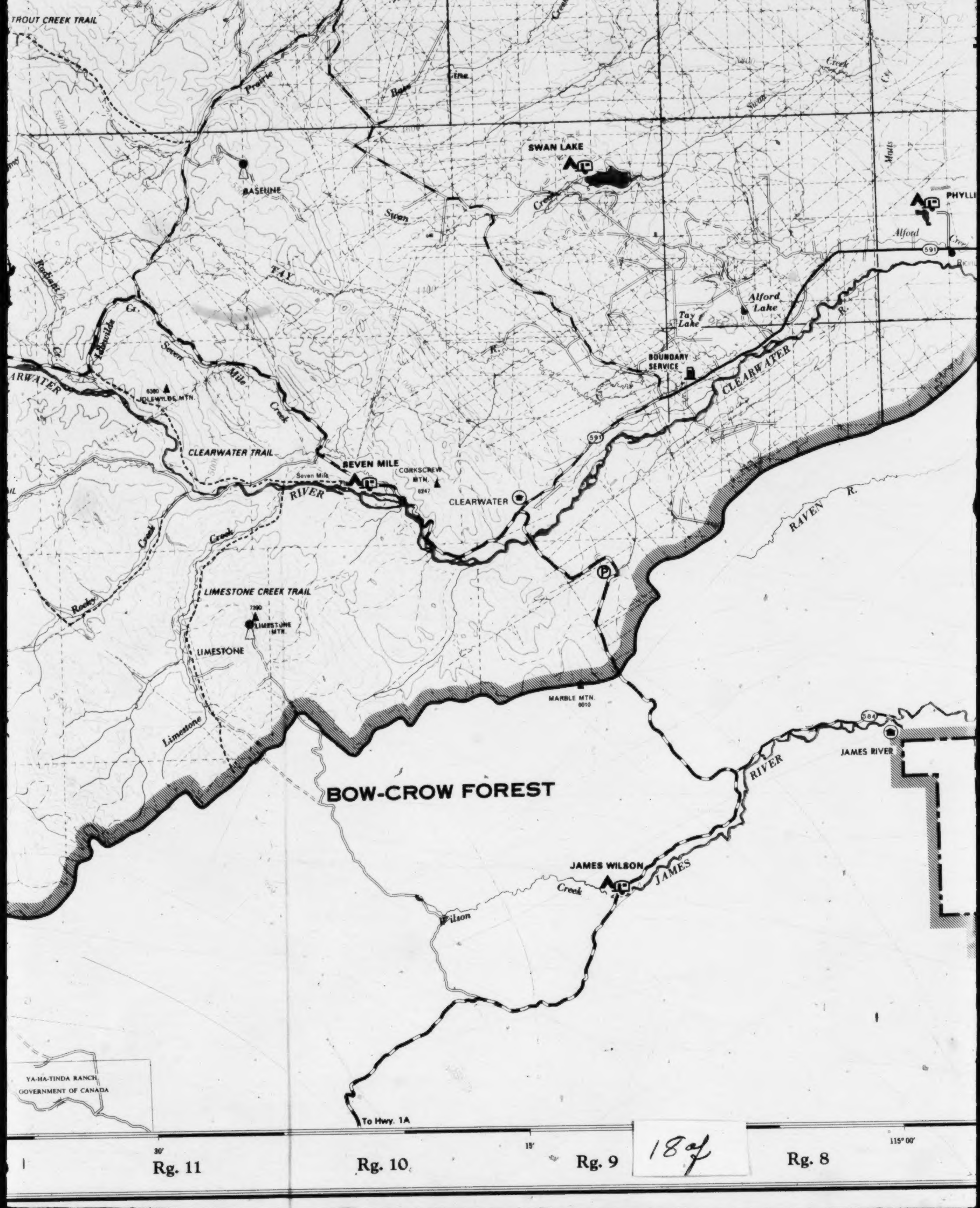
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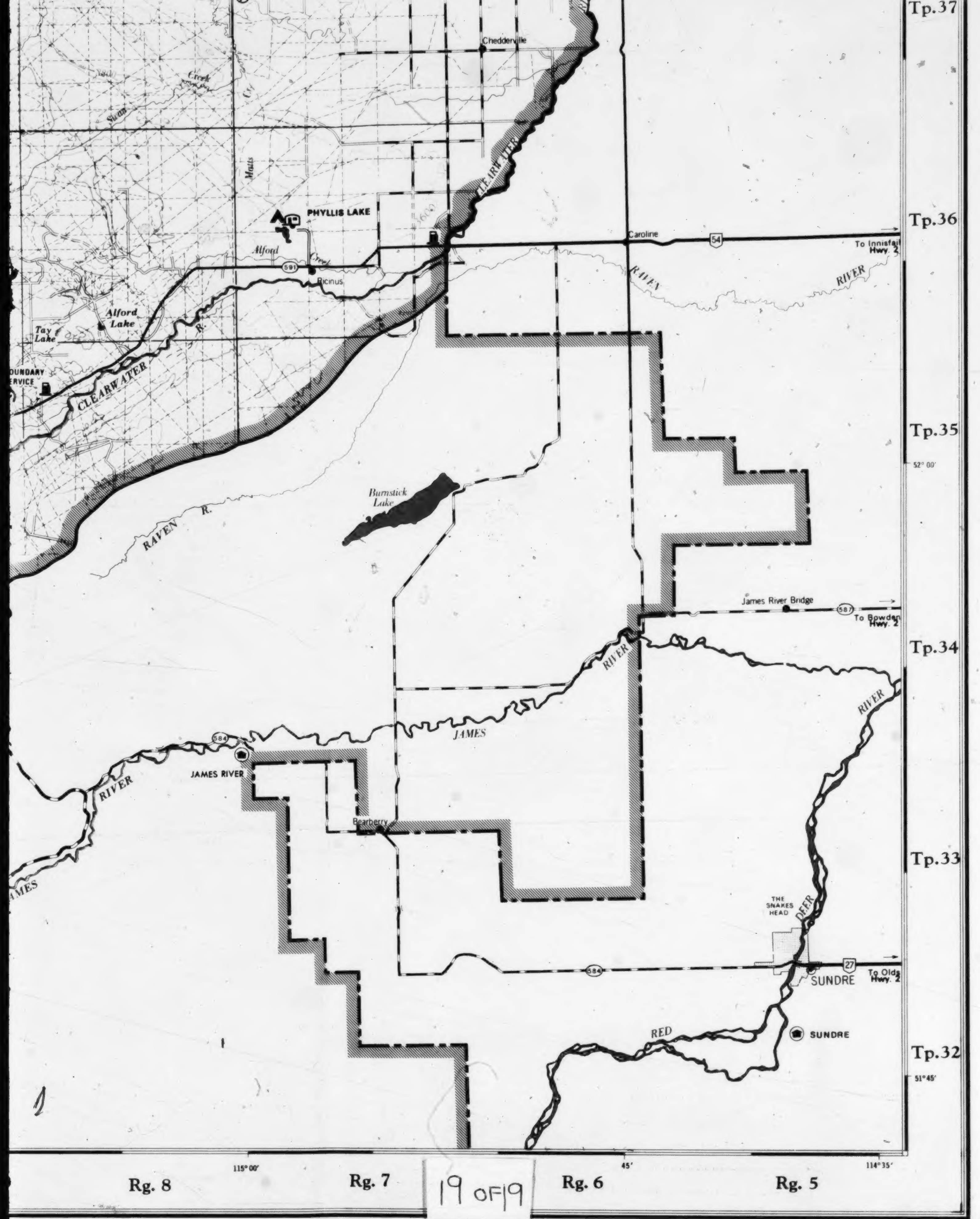
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YEAR THIS DEGREE GRANTED Fall, 1985

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DATED May 8 1985

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Potential Watershed Management Conflicts in the Upper North Saskatchewan Basin submitted by Brian M. Kelly in partial fulfilment of the requirements for the degree of Master of Science.

Arleigh H. Laycock

Supervisor

Edgar L. Jackson

Guy A. Swinnerton

Date May 5, 1985

Abstract

A highly single-use resource management and land use strategy has traditionally been applied in the upper North Saskatchewan Basin. Objectives for uses such as watershed, recreation, foresty, wildlife, etc. were never adequately defined in the East Slopes Policy or related management plans. Specific areas were allocated to exclusive uses. How these uses are managed, limitations to use, and potential use conflicts have not been considered in sufficient detail. Watershed management, recreation and conservation objectives, policies and management strategies are considerably different. This may lead to use conflicts. Watershed management may require environmental modification. Recreation and conservation uses require environmental protection and may limit active watershed management. As demands increase and a wider range of uses is encouraged, conflicts and environmental damage may occur due to deficiencies in the single-use approach.

A more comprehensive multiple-use, alternative futures approach to land use and resource management is required. Goals, objectives and standards should be defined for all uses. Alternative management strategies could be developed which stress different combinations, intensities and priorities of use. The strategy which best meets the goals and objectives should be implemented. Measures must be defined to determine if objectives and standards are being met. Monitoring and evaluation would ensure that goals and objectives are met and use conflicts and environmental damage are minimized. Effective resource allocation, flexible management and a better understanding of use limitations and conflicts should result. Greater resource benefits, fewer use conflicts, and less environmental damage should be possible in the long-term.

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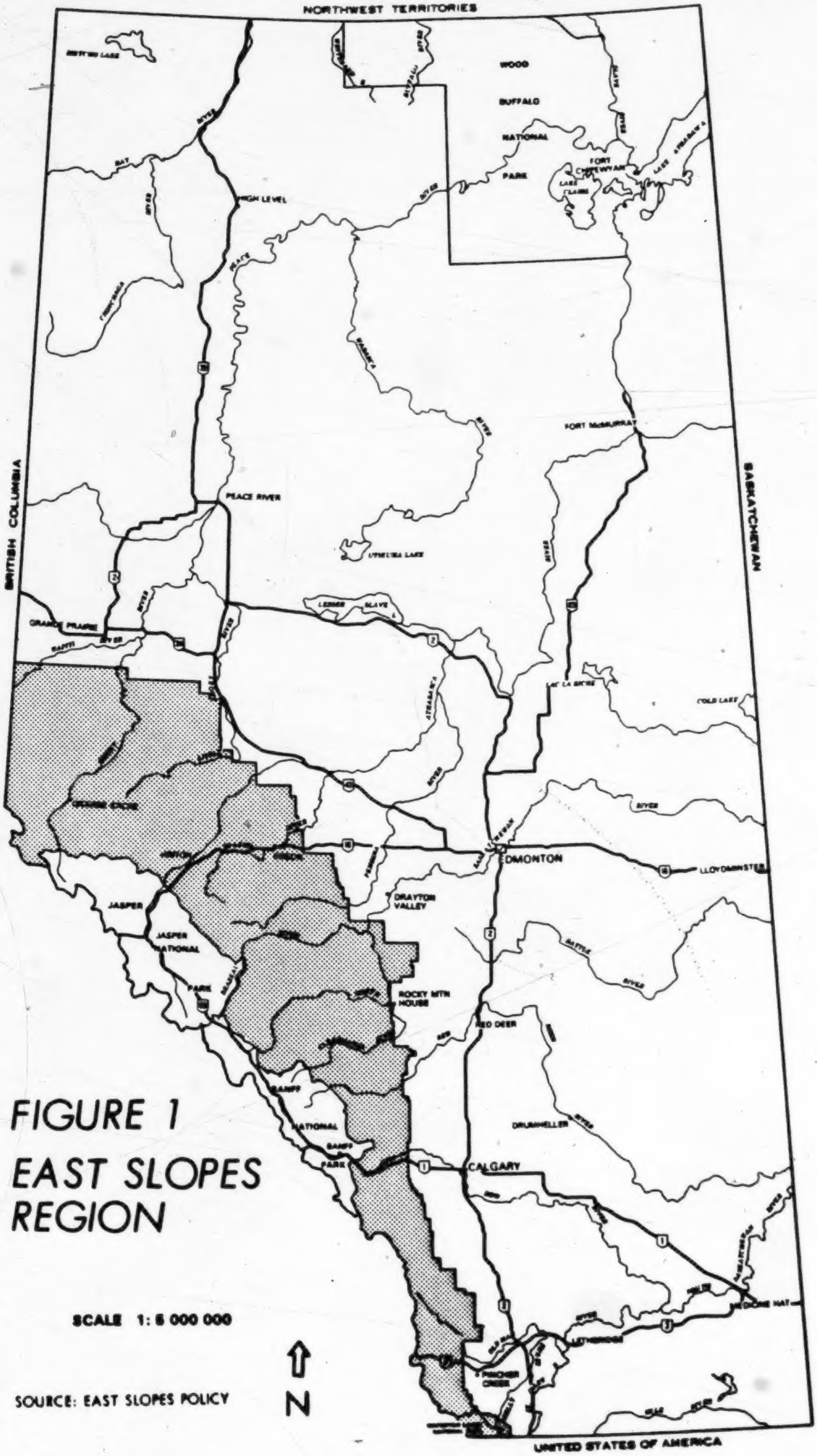
1. The Research Problem

1.1 Introduction

The East Slopes of Alberta's Rocky Mountains cover an area of over 90,650 km^2, consisting of rugged, forested mountain and foothills terrain (See Figure 1). This region contains a wealth of renewable and non-renewable resources such as water, scenery, timber, oil, wildlife forage and minerals. The majority of these resources are found on crown lands (Alberta Government 1977). Resource demands in this region have increased at a rapid rate in recent years and the extent of projected demands serves to highlight the fact that the resource base of the East Slopes is not unlimited. Growing pressure for land and resource development in the East Slopes region resulted in land use conflicts in some basins. The potential for future land use conflicts and concern for the protection of environmental quality, in this extremely important watershed region, highlighted the need for an integrated land use policy and a comprehensive plan for management and development.

To this end, the Government of Alberta initiated the Foothills Resource Allocation Study in 1970, to develop a comprehensive planning process designed to identify optimum resource uses for land units, based on evaluations of resource capability, present land use, economics and resource demand patterns (Alberta Government 1977). This exercise was followed up in 1973 by hearings conducted by the Environment Conservation Authority into "Land Use and Resource Development in the Eastern Slopes Region". These hearings were held in order to identify the views and concerns of Albertans, regarding the management of resources in this region (E.C.A., 1973).

In response to these needs and concerns, the Eastern Slopes Interdepartmental Planning Committee was established in 1975 to make recommendations on an integrated resource planning approach for management of the East Slopes. This culminated in the development of "A Policy for Resource Management of the Eastern Slopes," which served to identify broad land use priorities and resource management zones for the region (Alberta Government, 1977).


NORTHWEST TERRITORIES
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PEACE RIVER
BRITISH COLUMBIA
SASKATCHEWAN
UTIKUMA LAKE
LESSER SLAVE L.
GRANDE PRAIRIE
LAC LA BICHE
COLD LAKE
EDMONTON
LLOYDMINSTER
DRAYTON VALLEY
JASPER
JASPER NATIONAL PARK
ROCKY MTN HOUSE
RED DEER
BANFF NATIONAL PARK
CALGARY
DRUMHELLER
MEDICINE HAT
LETHBRIDGE
PINCHER CREEK
UNITED STATES OF AMERICA
N

FIGURE 1
EAST SLOPES
REGION

SCALE 1: 5 000 000

SOURCE: EAST SLOPES POLICY

General resource management and land use guidelines were also developed for each zone and these are included as part of the policy document. The "East Slopes Policy" was then used as a basis for development of integrated management plans (I.M.P.s) for all basins. Many of these plans are currently in the development stage, while other plans have been completed in recent years. However, despite these efforts to effectively manage the resources of the East Slopes region, there are some major deficiencies in the planning approach used. Perhaps the major limitation, involves the management of water resources in the East Slopes and a failure to recognize potential impacts of other land uses and management strategies, upon watershed conditions.

The importance of Alberta's East Slopes as a critical watershed has long been well recognized. (E.R.F.C.B. 1969). However, despite the importance of this area as a major source of water supply for the prairies, watershed management objectives necessary to effectively manage this valuable resource have never been adequately defined. Traditionally, watershed management has been oriented towards the provision of a high level of watershed protection, with the objective of improving upon natural streamflow (Laycock, 1973). However, there are three basic problems with this approach. First, a high level of watershed protection does not result in increased streamflow. Protection of vegetative cover, resulting in further growth and increased consumptive use, reduces the amount of water available for runoff and therefore results in a reduction of water yields. Therefore, the objective of yield improvement cannot be realized through a management strategy oriented towards vegetation protection. Secondly, this objective is based on the assumption that natural streamflow is adequate to meet existing and potential downstream demands and that there are no opportunities to enhance one or more components of streamflow. Third, the assumption is made that the objective applies equally to all East Slopes Basins. Regional variations in supply and demand patterns, very considerable differences in streamflow characteristics between different basins, and the different opportunities for change in these characteristics through watershed management, have not been considered.

The East Slopes region might produce considerable economic and social benefits for Albertans in adjoining areas, if the region were managed primarily to obtain an optimum flow of water (Laycock, 1957a). Optimum flow of water could be defined as streamflow of acceptable quantity, quality and regime in relation to downstream water requirements. Other uses such as forestry, grazing, mining, oil and gas, wildlife and recreation could be permitted if these activities did not interfere to any significant degree, with the achievement of optimum flow (Laycock, 1957a). Some of these uses could be encouraged if these contributed either directly or indirectly to the maintenance of optimum stream flow. However, management objectives for other uses have also never been adequately defined, in relation to watershed management.

Specific watershed management objectives must be defined for each basin. The watershed conditions required to attain optimum flow must also be identified. Management objectives and land use requirements should also be defined for all other potential uses. On this basis, these potential land uses could be assessed in relation to the required watershed conditions. Potential negative or positive impacts on these conditions could then be identified. Secondary land uses could be selected and appropriate management guidelines could be established to ensure that these secondary uses are well-integrated with watershed, in order to minimize potential management conflicts. This could be partially accomplished through the use of comprehensive watershed management plans outlining a management strategy for multiple resource use.

Well-defined objectives are necessary to ensure that watershed is given adequate consideration relative to other uses. The absence of well-defined management objectives could result in major use conflicts, deterioration of watershed conditions, and a subsequent change in water supply patterns, which might not be compatible with downstream demand. Development pressures within and outside the East Slopes region, existing and potential resource use conflicts and the dynamic nature of both downstream demand patterns and environmental conditions within each basin could cause major management and policy conflicts in the near future.

This high potential for conflict is based on the fact that a wide range of uses, such as forestry, grazing, mining, oil and gas developments, water resource developments, recreational facility development, enhancement of wildlife populations, and the preservation of the natural environment, are actively encouraged in the East Slopes region. Each of these uses has some degree of impact on watershed conditions and also limits the extent to which other uses can be optimized. Therefore, these uses could affect the degree to which watershed management objectives can be realized.

The major objectives of watershed management are to improve water yields, streamflow regime and water quality, reduce flood damage and control erosion and subsequent stream sedimentation and to maintain instream and streamside environmental quality (Laycock, 1965; Croft and Bailey, 1964). These objectives tend to be conflicting and cannot be maximized within the same basin. For example, if yield improvement is to be emphasized, transpiration losses should be reduced as much as possible (Satterlund, 1972; Laycock, 1965). This is usually accomplished by removal of vegetative cover, management of snow cover or other methods. However, when the natural vegetation is removed from a basin, erosion problems and flood damage can be increased substantially, streamflow regime is altered, and water quality generally deteriorates (Satterlund, 1972).

Alternatively, if the objective is one of improving seasonal streamflow patterns, maintenance and improvement of vegetative cover is extremely important (Hewlett and Nutter, 1969; Laycock, 1965; Kittredge, 1957). The development of vegetative cover will also reduce erosion and subsequent stream sedimentation problems and will usually improve upon water quality. (Satterlund, 1972; Newhall and Smith, 1964; Coleman, 1953). However, due to increased water losses through interception, surface detention and increased transpiration, the amount of water available for runoff is less and a decrease in water yield can be expected (Ward, 1972; Satterlund, 1972; Laycock, 1965).

All basins in the East Slopes have different patterns of existing resource use and downstream water demand. On this basis, specific objectives are required for each basin. Land use activities have different impacts on watershed conditions and affect the watershed output or streamflow characteristics in different ways. Some land use activities and intensities are compatible with the enhancement of specific watershed conditions and can be integrated with watershed management to a high degree. For example, if yield improvement is the main watershed management objective for a specific time period, block timber harvesting may be conducive to increased yields. However, if improvement of watershed conditions is required to improve upon water quality or regime aspects of streamflow, timber harvesting may not be compatible, as vegetation maintenance is required to meet these objectives. Since yield improvements may be desirable or physically possible in only a few basins, more specific watershed management objectives must be defined for each basin. Definition of objectives must be based upon an assessment of watershed conditions, patterns of downstream water demand, existing land use within the basin, opportunities for enhancement, and the potential for deterioration in watershed conditions with changes in land use. The projected future demand patterns for both upstream and downstream water use must also be assessed when defining watershed management objectives.

A major principle of resource management is that most resource uses conflict with other uses to some extent (O'Riordan, 1971; Dasmann, 1964; Ciriacy-Wantrup, 1952). The degree of potential conflict may range from very minor use conflicts to mutually exclusive resource use depending upon the types and intensities of resource use involved. In some cases, different resource uses may be complementary in some ways or at some stages (Laycock, 1957a). For example, wildlife management objectives may complement watershed objectives in some cases and be conflicting in other situations. Therefore, in order to achieve a high degree of resource use integration, where conflicts are reduced to a minimum level, well defined management obectives are required for all uses (Holling, 1978).

Once management objectives and the requirements of each objective have been identified, it is then possible to assess the degree to which conflict will occur if two or more uses are emphasized within the same area (e.g. watershed protection vs. forestry). On this basis, limitations to individual uses can be identified, and potential trade-offs can be evaluated. Various resource management objectives may then be balanced to achieve optimal resource use, with minimal environmental deterioration. Due to the considerable importance of watershed as a resource use, it is clearly evident that well defined watershed management objectives are essential to integrated resource management in any multiple-use situation.

Since resources and related demand patterns are changing through time, all management objectives must be flexible, to ensure that changing demands can be accommodated in the long-term. In order to realize a high degree of resource integration and to ensure optimal use through time, there are three basic requirements:

1. The resource base must have the physical capability to sustain the resource use or combination of uses specified in the management objectives. In terms of watershed management, this must include an assessment of both resource use within the basin and downstream water requirements.
2. The nature and intensity of potential resource management conflicts and limitations must be identified, both in terms of environmental impacts and conflicts in management policy.
3. A methodology for assessing the implications of resource management conflicts and the trade-offs involved is required in order to balance long-term management objectives, to ensure optimal resource use in the context of environmental, economic, social and cultural limitations.

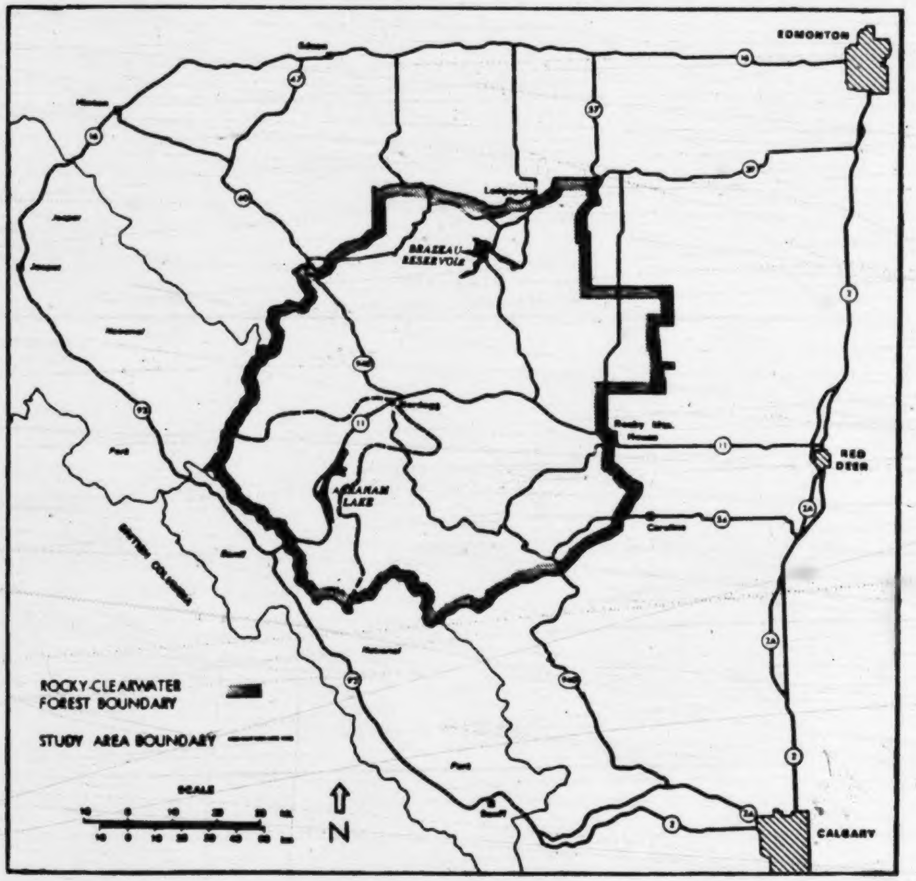
In Alberta, resource management objectives are generally not well defined and there has been little consideration given to integrating land uses or managing lands for multiple uses. This highly single-use orientation, although adequate in the past, will not be an appropriate management strategy in the near future. Therefore, a more comprehensive, multiple-use approach is recommended. The first step toward attaining balanced multiple-use resource management is the definition of watershed management objectives for each basin. Since "watershed" is the identified "prime use" of the East Slopes Region, all resource development and land use proposals should be evaluated against the watershed management objectives defined for each basin (Alberta Government, 1977; E.R.F.C.B., 1969). Therefore, such plans would be assessed on the basis of the degree of conflict with the "ideal" watershed conditions required to meet the watershed management objectives. On this basis, the degree of potential use conflicts and environmental impacts could be assessed. Appropriate resource management guidelines could then be developed to ensure minimal conflict with both watershed conditions and other resource uses. Therefore, the impacts of various combinations and intensities of use could be identified. Potential trade-offs could be assessed, and the best combination of uses selected, in order to optimize use of the available resources.

Development pressures within, as well as outside the East Slopes, exisiting and potential use conflicts, combined with the dynamic nature of downstream demand patterns, on-site demands and environmental conditions, results in considerable pressure on the resource base of this region. Conflicts in management and policy objectives and a highly single use orientation to land use and resource management increase the potential for use conflicts and environmental degradation. Therefore, the research problem is essentially one of defining watershed management objectives which are basin specific, reflect regional variations in water supply and demand patterns and opportunities for improvement with management. The impact of secondary uses on the maximization of watershed management objectives must also be assessed.

1.2 The Upper North Saskatchewan Basin

The upper North Saskatchewan Basin, just east of Banff National Park, will be used as a study area for the purposes of illustrating the need for well defined, management objectives for watershed and other uses, in each East Slopes basin. (See Figure 2). As part of the Saskatchewan Basin, the study area is of considerable importance in terms of downstream demand patterns and existing water resource developments for streamflow regulation. The potential for increased flow regulation, possibility of increased on-stream storage and the fact that the area is being considered for major provincial park development, could result in considerable use conflicts in the future.

FIGURE 2
LOCATION OF THE STUDY AREA


EDMONTON
16
47
37
39
40
BRAZEAU RESERVOIR
Jasper
National
93
11
Nordegg
Rocky Mtn. House
11
RED DEER
2
ABRAHAM LAKE
Park
BRITISH COLUMBIA
Banff
Caroline
2A
National
93
Park
Banff
1
2
CALGARY
ROCKY-CLEARWATER FOREST BOUNDARY
STUDY AREA BOUNDARY
SCALE
N

SOURCE: ALBERTA FOREST SERVICE-1983

1.3 Potential For Watershed Management - Park Development Conflicts

The Alberta Government has recently alluded to the possibility of major recreational developments for the study area. Although no development would be anticipated for at least five to ten years, the long-term potential is extremely high. At a maximum level, the extent of development could be similar to Kananaskis Country and could include the entire study area as well as large portions of the Athabasca and Brazeau basins (Edmonton Journal, Nov. 5, 1981). The David Thompson Country concept calls for recreational developments within an area extending roughly from the National Park boundary east to Nordegg, then extending in a north-south direction from the Wildhay River, north of Hinton, south to the Ram River, some 75 km south of Nordegg (Edmonton Journal, Nov. 5, 1981).

At a minimum level, a single provincial park could be developed in the North Saskatchewan River Valley, surrounding the Kootenay Plains Natural Area (Alberta Recreation and Parks, 1983). Such a park would likely range in size from 10 - 25,000 hectares and would effectively join the two Wilderness Areas and Kootenay Plains into a contiguous management unit. This would essentially mean that all lands which are manageable from a watershed management standpoint would be designated as a provincial park, natural area, or wilderness area.

The environmental impact of such developments is difficult to predict. However, the potential for watershed damage and subsequent alteration of streamflow characteristics could be substantial. For example, the potential for forest fires increases with recreational use. Poorly constructed or informal trails and random use in fragile areas, such as the Kootenay Plains could accelerate erosion and increase stream sedimentation. The construction of roads, trails and major facilities such as ski areas, requires large scale removal of vegetation which also increases the erosion/sedimentation potential.

If it is desirable for watershed management purposes to increase water yields, without any concern for sedimentation or regime, then perhaps such developments are complementary. However, if it is desirable to minimize erosion and enhance regime through the maintenance of vegetation, such developments would be conflicting and special measures would be required to ensure some degree of compatability. Therefore, watershed management objectives should be defined prior to any land allocations or site development takes place. On this basis, conflicts with the "prime use" (watershed) can be assessed and trade-offs can be realistically evaluated in the decision-making process.

The definition of watershed management objectives is also highly desirable in terms of park development. Water resource management activities, especially those of a structural nature, often create conditions which detract from the aesthetics and environmental conditions desirable from a conservation standpoint. For example, TransAlta Utilities is currently evaluating increased flow regulation at the Bighorn Dam, which would result in greatly increased drawdown, leaving more extensive mud flat areas exposed for a longer period, along the Abraham Lake shore line. In the medium to long term, additional storage within the study area might be desirable. Similarly, other structural options or the use of vegetation manipulation techniques, such as sanitation cutting or phreatophyte removal, may be desirable for the enhancement of watershed conditions. This could conflict with park management objectives, such as preservation of the natural environment and could limit recreational use in large areas of the basin.

The policy and land management implication of emphasizing either park objectives or watershed management objectives, is an important consideration at this point. Alberta Recreation and Parks could assume a lead agency role, if there is any major park development in the upper basin area. The management orientation might be shifted more towards emphasis of park objectives. This change might limit future opportunities for watershed enhancement.

On the basis of these potential conflicts, better definition of management objectives for all potential uses is required. A framework to assess and balance these objectives in the context of long-range planning is also necessary, to ensure a high degree of integrated use with minimal conflict. The obvious prerequisite for any such assessment is the definition of watershed management objectives for the upper North Saskatchewan Basin. The "Policy for Resource

Management in the East Slopes" identifies watershed as the prime use in all East Slopes basins, with all other uses being subordinate (Alberta Government, 1977). Watershed management objectives should be defined to meet regional needs, including downstream demands, as well as demands within the basin. These demands could then be assessed in relation to existing and potential water supplies. Once the objectives have been defined, management strategies required to realize these objectives could be developed. The objectives for other uses and related management requirements could then be assessed against these watershed management objectives. The trade-offs associated with these other uses could be assessed in order to balance long-term management objectives. On this basis, several other uses might be possible in the basin, without compromising the watershed conditions necessary to realize watershed management objectives.

1.4 Research Objectives

The present patterns of development in the upper North Saskatchewan Basin are the result of an evolution of resource demands and the management strategies selected to meet those demands. Many alternative management and development options are possible, each maximizing a different set of policy objectives, which in turn leads to different use patterns. On this basis, the objectives of the author of this thesis are:

1. To review the orientation of watershed management in the East Slopes with particular reference to the upper North Saskatchewan Basin, to identify and evaluate deficiencies in this traditional approach.
2. To complete a highly generalized assessment of watershed conditions and to identify ideal land management requirements for "watershed" purposes, in relation to both on-site and downstream water demands.
3. To define realistic watershed management objectives for the study area, on the basis of the assessment identified in 2 and on the basis of existing and potential on-site and downstream water requirements.

4. To define in general terms, possible park development and resource conservation options and management objectives and evaluate the extent to which these uses could conflict with watershed management objectives.
5. To outline an alternative approach for planning, managing and evaluating multiple resource uses and identifying and resolving potential conflicts between these uses.
6. To use this approach to describe and evaluate use conflicts and potential management alternatives for the upper North Saskatchewan Basin.

In order to fulfill these six objectives, this thesis has essentially been divided into three parts. Limitations to the existing management strategies applied in the study area, as emphasized by various single-use assessments and by the East Slopes Policy and related planning exercises, are described in chapter 3. In the second part, (chapters 4, 5, and 6), ideal management requirements for both watershed and park uses are outlined and existing and potential conflicts between these uses are described. In the third part, (chapters 7 and 8) an alternative management approach is described and applied to the solution of potential problems in the study area, using hypothetical situations. This process is mainly used as an example, to illustrate the major deficiencies in the East Slopes Policy approach to land use and resource management. By using the study area as an example of a potential problem, the need for the use of an 'alternative futures' approach to management should become evident. On this basis, use of such a process could result in better management of land and resource use in the long-term, with fewer use conflicts.

1.5 Definition of Terms

There are several terms used extensively in this thesis which require definition. The definitions outlined below are those of the author and will apply to this thesis only.

Watershed Management

Watershed management is a comprehensive term which applies to a wide range of techniques employed to maintain or improve upon one or more components of streamflow-

(yield, regime, or quality). The techniques employed could range from the total protection of a basin, through a complete prohibition of land use, to the complete removal of forest cover over an entire basin. Watershed management would also include a wide range of structural and non-structural techniques such as snow pack management, vegetation modification, construction of storage reservoirs, channel modifications, stream diversion, interbasin transfer and other techniques. The actual types, combinations and intensities of management techniques applied, would vary from basin to basin. The type and intensity of management required, would vary with the degree of emphasis placed upon yield, regime or quality, existing watershed conditions and the degree of modification or improvement that is physically possible. Watershed management may also include the utilization of other land use activities to obtain the watershed conditions required to meet specific objectives (e.g. forest harvesting to improve stream yields).

Watershed Protection

Watershed protection includes all measures designed to protect existing watershed conditions. This could include the application of a wide range of measures to protect vegetation from fire, insect infestations, tree disreases, or land use impacts. Watershed protection would also include measures to improve slope stability, protect stream bank vegetation and to control soil erosion. The application of land use controls to prevent deterioration of watershed conditions would be one method of providing watershed protection. Indirect watershed protection could also be provided through specific land allocations to uses such as wilderness areas or parks, but this would also require complementary land use guidelines.

Water Resource Management

Water resource management refers to the management of water resources for the maintenance or improvement of on-site and/or downstream conditions. This would largely be accomplished through the application of structural techniques such as channelization, construction of dams and reservoirs, and interbasin transfers. The construction of facilities for production of hydroelectric power or flood control structures would also be considered as water resource management.

Park Management (Park Development)

Park Management refers to the allocation, development and management of lands for outdoor recreation and natural resource conservation purposes. This general term would apply to the construction and operation of recreational facilities and to park resource management and conservation programs. Three specific terms also are included in this general definition; wilderness management, natural resources conservation, and outdoor recreation management.

Wilderness Management

The term wilderness management pertains to all principles, objectives and management guidelines relating specifically to the management of Wilderness Areas, Natural Areas, and Ecological Reserves, as defined in the existing legislation (Wilderness Areas, Natural Areas and Ecological Reserves Act, 1981).

There are two philosophies of wilderness management; biocentric and anthropocentric. The biocentric philosophy emphasizes preservation of the natural order by allowing natural processes to continue, by discouraging active management or use (Hendee, Stankey and Lucas, 1978). The anthropocentric approach emphasizes active management of wilderness for mans use and enjoyment, for uses such as recreation and watershed. This may include the modification of the physical environment or the natural order, through management. (Hendee, Stankey and Lucas, 1978). In Alberta, the biocentric approach has traditionally been applied to the management of Wilderness Areas.

Natural Resources Conservation

Natural resources conservation is the resource protection mandate of park agencies such as Parks Canada and Alberta Recreation and Parks. This term also applies to the principles, objectives and land use guidelines associated with park resource management and protection activities.

Outdoor Recreation Management

Outdoor recreation management refers specifically to the development, management and operation of recreational facilities generally associated with a national or provincial park. These facilities would include campgrounds, day use areas, hiking and equestrian trails, ski areas and service centers. This term also refers to the management of recreational use in both facility and backcountry areas, and all other activities associated with the outdoor recreation mandate of park agencies. In addition, this term will also apply to these programs and activities where these occur outside of park boundaries. For example, this term would also apply to hiking and other recreational activities on any public lands.

2. Description of the Study Area

2.1 Study Area Boundaries

The upper North Saskatchewan basin extends from the Saskatchewan Glacier at the Columbia Icefields, east to the Brazeau Gap. The Basin covers approximately 1720 km^2. The study area includes approximately 85% of this area (1450 km^2) and extends from the Banff National Park boundary east to the Bighorn Dam. (Figure 3) This includes the drainage basins of the Siffleur River, Whiterabbit Creek, Cline River, Allstones Creek and several smaller creeks draining areas of the North Saskatchewan River Valley. The entire study area is located in the Rocky-Clearwater Forest with all lands being owned by the Crown. This area generally corresponds to the area known as Conservation Unit R-6 during the tenure of the Eastern Rockies Forest Conservation Board (E.R.F.C.B.).

The upper North Saskatchewan basin can be subdivided into four major sub-basins; the Upper Saskatchewan, Cline, Middle Saskatchewan and Bighorn (Figure 4).[1] The study area includes the first three sub-basins. The Bighorn sub-basin is excluded from this assessment because the Bighorn River enters the North Saskatchewan, downstream from the Bighorn Dam. The portion of the Middle Saskatchewan Basin, downstream from the Bighorn Dam, has also been excluded from this assessment. Each sub-basin is different in terms of vegetation patterns and watershed conditions. In each sub-basin, there are also different opportunities for watershed management or enhancement and different levels of potential recreational use and facility development. Therefore, different levels of resource use conflicts are possible.

There are three significant land reservations for natural resource protection purposes in the Basin (see Figure 3); the Kootenay Plains Natural Area (24 km^2) the Siffleur Wilderness Area (254 km^2) and most of the Whitegoat Wilderness Area (275 km^2). These areas represent approximately 40% of the Basin. The study area also includes the Abraham Lake reservoir,

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[1] The upper Saskatchewan sub-basin includes two major tributaries, Siffleur River and Whiterabbit creek. In later portions of the thesis, these are referred to as the Siffleur and Whiterabbit sub-basins. The Middle Saskatchewan sub-basin contains Abraham Lake.

FIGURE 3
THE UPPER NORTH SASKATCHEWAN BASIN

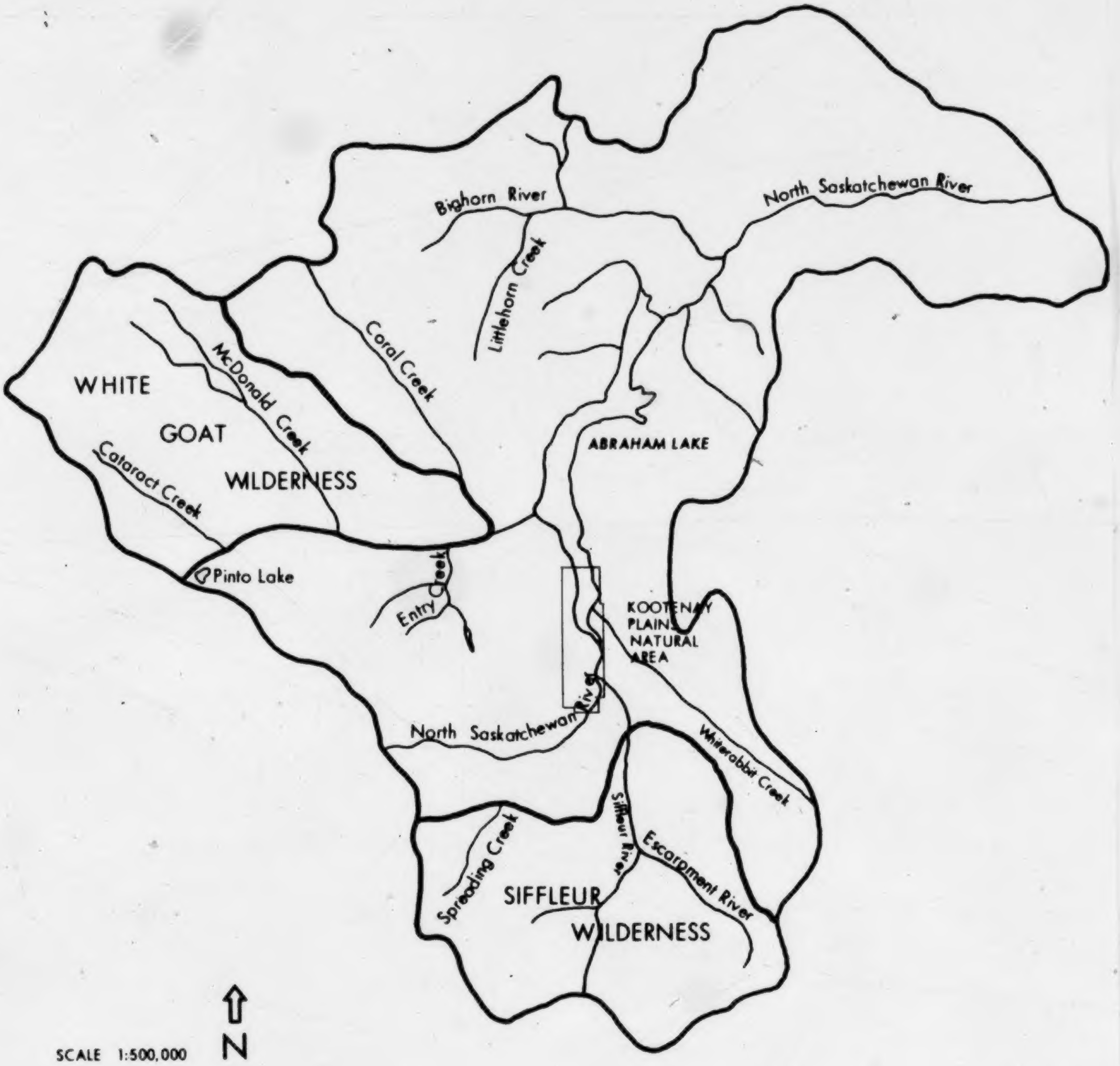
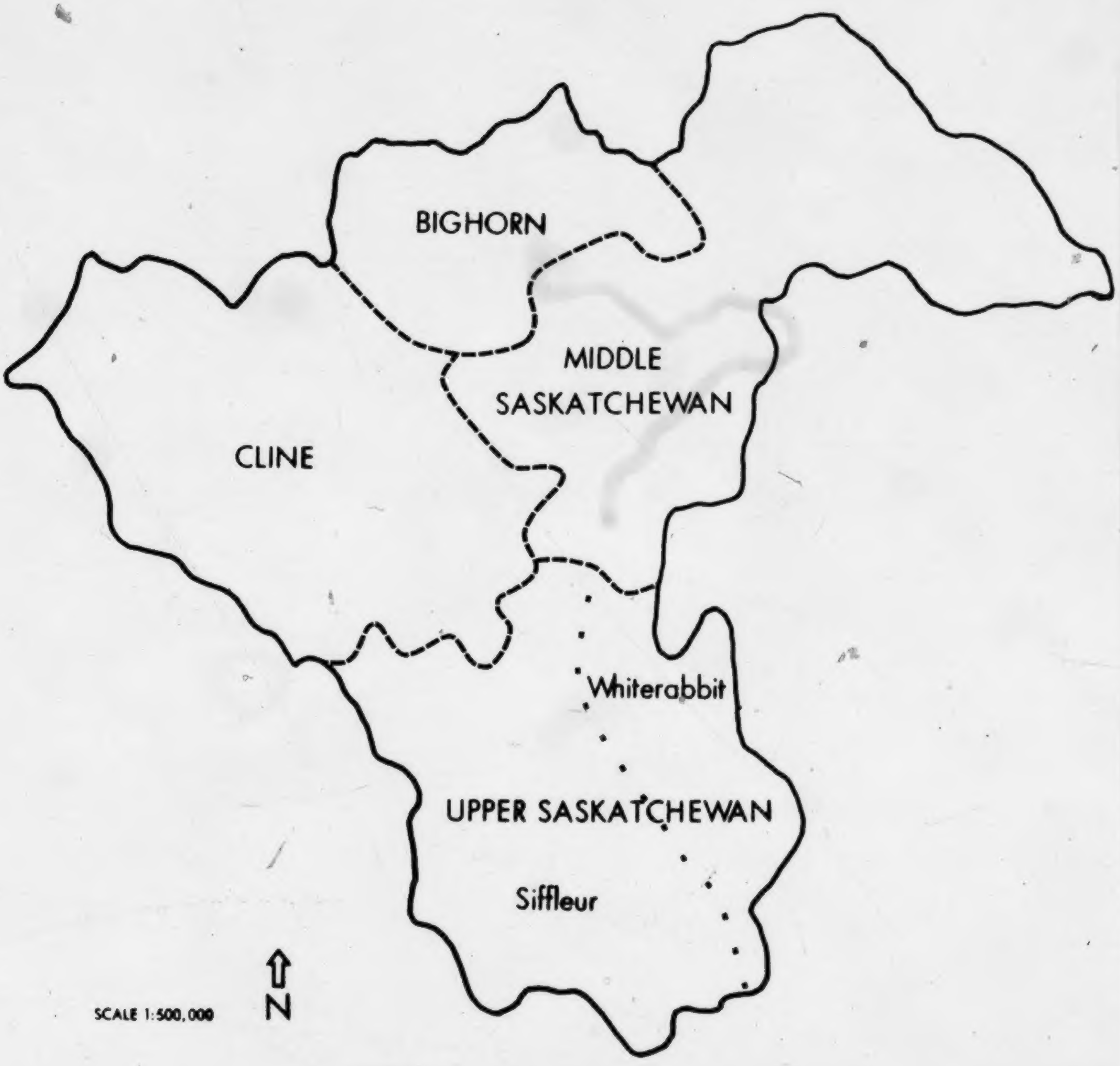

Bighorn River
North Saskatchewan River
Littlehorn Creek
Coral Creek
McDonald Creek
WHITE
GOAT
WILDERNESS
Cataract Creek
ABRAHAM LAKE
Pinto Lake
Entry Creek
KOOTENAY
PLAINS
NATURAL
AREA
North Saskatchewan River
Whiterabbit Creek
Spreading Creek
Siffleur River
Escarpment River
SIFFLEUR
WILDERNESS
N
SCALE 1:500,000

FIGURE 4
SUB-BASIN BOUNDARIES


BIGHORN
MIDDLE SASKATCHEWAN
CLINE
Whiterabbit
UPPER SASKATCHEWAN
Siffleur
SCALE 1:500,000
N

which covers roughly 32 km^2 of the North Saskatchewan Valley, upstream from the Bighorn Dam. The implications of these land reservations relative to potential resource management conflicts will be assessed in subsequent chapters.

Access to the study area is provided by Highway 11 which runs parallel to the North Saskatchewan River between Rocky Mountain House and Saskatchewan Crossing where it joins the Ice Fields Parkway (N.P. 93) in Banff National Park. As a result, there is relatively heavy recreational traffic on this route. Trail access is provided along the Cline and Siffleur Rivers and the area has an extensive network of informal back country trails. Some of these trails are connected to the National Park trail system and to the Great Divide Trail. Extensive pack horse trails are also found in the Cline River Valley and Coral Creek basin. A network of forestry roads and seismic lines has also been constructed in the extreme eastern portion of the study area, near the Bighorn Dam site.

The North Saskatchewan valley area has had a long history of use by Indians. The open grasslands and considerably milder temperatures provided an excellent winter camp and grazing area for their horses. Anthony Henday visited the area in 1755 during the course of his early explorations of Western Canada. David Thompson travelled through the upper North Saskatchewan valley area on his journey to the West Coast in 1807. Around 1802, a trading post was established near Rocky Mountain House. Kootenay Indians from the interior of B.C. travelled to this post and camped on the open plains near the mouth of the Cline River and as a result this area became known as the Kootenay Plains. Another early explorer, Joseph House travelled through the area in 1809. In 1892, a band of Stoney Indians broke away from the main band at Morley and settled on the Kootenay Plains and remained in the area for several years (Underwood McLellan, 1970). In 1947 the Bighorn Indian Reserve was established for these people, approximately 15 km east of the Bighorn Dam (Underwood McLellan, 1970).

The grazing potential of the Kootenay Plains attracted two pioneers named Barnes and Wilson to the area around 1900. Two horse ranches were established in the valley; Barnes settling near the mouth of the Siffleur River in the west, Wilson settling near the mouth of

Whiterabbit Creek near the Bighorn Damsite. These ranches were later abandoned, as the profitability of horse ranching declined.

In subsequent years, the Kootenay Plains area was used extensively by guides and outfitters operating in Banff National Park, as a winter horse pasture. Parks Canada's horses were also pastured in this area. This arrangement continued until the early 1970s. The establishment of the Kootenay Plains Natural Area limited the use of the area for winter pasture. In addition, many applications for cattle grazing in this area have been made over the years. However all such applications were refused, largely on the basis that this was an incompatible use, given the environmental significance of the Kootenay Plains.

2.2 Present Day Land-Use Activity

The upper North Saskatchewan Basin has a very limited potential for oil and gas developments, mining and forestry. Oil and natural gas explorations have been carried out in the eastern portion of the study area. Although some test wells were drilled in the Tershishner Creek area in the early 1960s, no recoverable deposits were found. The study area is believed to have a relatively low potential for both oil and natural gas production. (E.R.F.C.B., 1969). However, much of the eastern portion of the study area is still covered by miscellaneous reservations for oil and natural gas exploration.

There have also been extensive coal explorations in the eastern portion of the study area and in areas adjacent to the Bighorn sub-basin. There are currently several coal reservations in the Tershishner and Allstones Creek areas, however, there have not been any significant finds in these areas (Landals, 1973). There are some proven coal reserves in the Bighorn sub-basin (adjacent to the study area), but no developments are contemplated in the forseeable future. This is largely due to the existence of more viable opportunities in the Robb, Luscar and Grande Cache areas and the current glut in world coal markets (E.R.F.C.B., 1969).

The capability for forestry is also relatively low, in most areas of the Basin. Although some logging has occurred along the eastern margin of the study area, the Basin has never produced much merchantable timber. At present, all logging operations are well outside of the study area. The absence of commercial forest operations within the study area is due largely to a combination of difficult terrain conditions and the existence of very marginal or recently burned-over stands in many areas of the Basin. Land allocations, such as the Whitegoat and Siffleur Wilderness Areas have also limited these resource uses.

The Kootenay Plains area has some commercial grazing potential. This area has been used for grazing in the past and there is some demand for this land use. However, grazing has been prohibited under existing land use policies and by the designation of the Kootenay Plains as a natural area. The Ermineskin Indian band occupied portions of the Kootenay Plains in the late 1960s, but discontinued this occupation in the early 1970s (Underwood McLellan, 1970).

Despite a low potential for many resource uses, the upper North Saskatchewan Basin is a valuable natural resource. Most of the flow of the North Saskatchewan River rises in or passes through the study area. Watershed is perhaps the most important use, as most of the North Saskatchewan River Valley is held under a resource development reservation for water power development (Landals, 1973). A considerable portion of the North Saskatchewan River Valley was also flooded following construction of the Bighorn Dam in 1969.

The North Saskatchewan Valley is also an excellent ungulate range, supporting a high population of deer and elk (Stelfox, 1972; E.R.F.C.B., 1969). Moose and black bear are also found within the Basin as well as bighorn sheep, grizzly and many species of smaller mammals (Stelfox, 1972; Landals, 1973).

In recent years, land use policies have emphasized outdoor recreation and resource conservation as major uses for the Basin. The study area has a long history of recreational use for a wide range of activities. The rugged, picturesque mountains and valleys, the uniqueness of the Kootenay Plains, and a varied and moderately large wildlife population, ensures continued recreational use (E.R.F.C.B., 1969). Proximity to the National Parks and ease of access enhances the recreation potential of the Basin.

As a result of these environmental factors, trail riding, sight seeing, and hunting were traditional recreational pursuits. At present, recreational use includes backcountry hiking and camping, auto access camping in the valley area and some mountain climbing, in addition to these traditional uses. The study area also includes several significant natural features and large areas of essentially undisturbed lands.

The significance of some of these natural resources was recognized by the Alberta Government and some protection from damage was ensured, with the establishment of the White Goat and Siffleur wilderness areas in 1961 and the Kootenay Plains Natural Area in 1968. The Wilderness Areas were established to preserve their unique beauty and natural character, and to safeguard these areas from infringement, development or occupation (Alberta Recreation and Parks, 1981a).

The White Goat Wilderness Area is bounded on the west by Banff and Jasper National Parks, on the south by the Cline River and on the north and east by the drainage divide which separates the McDonald Creek, Coral Creek and Job Creek watersheds (Alberta Recreation and Parks, 1981b). The White Goat Wilderness Area consists of a series of high mountain ranges separated by wide valleys and contains a few small alpine lakes and several major streams such as Cataract, McDonald and Boulder Creeks, which are tributaries of the Cline River.

The Siffleur Wilderness Area is located south of the North Saskatchewan River and is bounded on the west and south by Banff National Park. The north boundary is an imaginary line located 4.8 km south of the North Saskatchewan River, which follows the meandering of the river east to a point where the line crosses the Siffleur River (Alberta Recreation and Parks, 1981a). The boundary then follows the drainage divide south and west to the Banff National Park boundary. The Siffleur Wilderness Area is surrounded by a high mountain range forming the Siffleur drainage divide and extending to elevations in excess of 3000m at some points. The one major break in the perimeter, with the exception of the north boundary, is the Siffleur River Valley, which joins the North Saskatchewan Valley. Corona, Spreading, Loudon and Porcupine Creeks and the Siffleur and Escarpment Rivers drain this area.

The Kootenay Plains Natural Area was established to preserve the fragile and ecologically unique "rangeland" area of the North Saskatchewan Valley. (See Plate 1). The presence of these semi-arid plains within an alpine environment provides an excellent winter range for wildlife most notably deer, and also serves to enhance the ecological diversity of the basin.

The existence of these environmentally significant areas combined with much improved access ensures that recreational use will remain high. Recreational pressure in backcountry areas has increased in recent years. In addition, a number of guides and outfitters have traditionally operated in the Basin, mainly in the Cline River, Coral Creek and Cataract Creek areas. These trips are popular for hunting, fishing and sightseeing.

The Alberta Government has also recently approved development of the controversial Odyssey project. The Odyssey, located near Abraham Lake, east of the Cline River, is a major resort complex which will provide accommodation, convention, and on-site recreational facilities, including a major golf course. It is anticipated that construction of this complex will result in increased use of the North Saskatchewan River Valley, for a wider variety of recreational pursuits.

2.3 Physical Description

2.3.1 Geology and Geomorphology

Three distinct geologic units are represented in the upper North Saskatchewan basin; the main ranges, front ranges and the foothills. The main ranges are characterized by flat lying or gently folded sedimentary rocks, which have been uplifted and separated from the highly deformed front ranges by the Lewis Thrust Fault (McPherson, 1970; Pettapiece, 1971; Rutter, 1965). The main ranges exist along the western boundary of the study area and are comprised of Pre-Cambrian and Cambrian limestones, quartzites and dolomites, with small sandstone and shale deposits, which outcrop along the eastern edge of a large syncline (Pettapiece, 1971;

Plate 1: The Kootenay Plains

The Kootenay Plains provide a sharp environmental contrast to the mountainous terrain surrounding the North Saskatchewan Valley.

Rutter, 1965).

The front ranges include the mountains of the First, Ram and Bighorn ranges as well as the conspicuous outliers which form the Brazeau Range (E.R.F.C.B., 1969). The front ranges consist of complexly folded and faulted, west-dipping thrust sheets, with formations varying in age from Paleozoic to lower Mesozoic and consisting of limestones, dolomites, shales and sandstones (Richmond, 1965; Rutter, 1965). In contrast, the foothills unit consists of large, flat lying thrust sheets, overlain by Mesozoic sediments. Coal seams are found in the lower Cretaceous formations of the foothills and eastern front ranges (Richmond, 1965; North and Henderson, 1954).

The present day topography of the study area is of glacial origin. Pre-glacial streams kept pace with orogeny, thereby maintaining steep-sided, narrow gorges across the uplifting mountain ranges during the Tertiary (Richmond, 1965). In the Pleistocene, glacial advances and recessions widened and deepened the major valleys, most notably those of the North Saskatchewan, Cline and Siffleur Rivers (McPherson, 1970). The subsequent deglaciation roughly 10,000 to 6,000 years B.P. resulted in the deposition of stony, calcarious till, which filled valley bottoms and blanketed lower mountain slopes (Heusser, 1956; McPherson, 1970). Meltwater streams in turn, deposited outwash material in the main valleys (McPherson, 1970). Present streams continue to sort the immense deposits of glacial detritus, forming large, braided floodplains along the North Saskatchewan River (Landals, 1973; Pettapiece, 1971). The Saskatchewan Glacier provides a major source of run-off for the North Saskatchewan River. Due to glacial origins and subsequent sediment loading, meltwater rising in the Icefields gives the North Saskatchewan River a characteristic milky blue appearance.

Many of the steep gradient tributary mountain streams also carry large bed loads, which are deposited as alluvial fans, in the North Saskatchewan River valley (McPherson, 1970). As a result, the major geomorphic process responsible for the present valley topography, has been the development of the alluvial fans (Pettapiece, 1971; McPherson, 1970). These landform features are especially evident along the North Saskatchewan River Valley in the

Kootenay Plains area. Another recent phenomenon is the deposition of loess over much of the terrain at lower elevations, in the North Saskatchewan River Valley (Pettapiece, 1971). This loess material is transported from sandy areas upstream, by aeolian processes, and deposited over a large area of the North Saskatchewan Valley, in the vicinity of the Kootenay Plains.

2.3.2 Relief

There is considerable topographic variation within the upper North Saskatchewan Basin. Elevations range from 1,066m in the North Saskatchewan River valley to the 3,361m summit of Mount Cline, which is the highest peak in the study area. There are also several peaks exceeding 3,050m in elevation, some of which are capped by small glaciers. Sixty-five percent (65%) of the land surface in the Cline and Upper Saskatchewan sub-basins lies above 1,980m while 14% of the land surface in the less mountainous Middle Saskatchewan sub-basin lies above this elevation (E.R.F.C.B., 1969).

The topography of the basin is reflected in the slope distribution curves. Slope distribution curves calculated by the E.R.F.C.B. using the Linsley, Kohler, and Paulhus method, indicated that mean slope figures ranged from 29.2% in the rolling foothills area of the Middle Saskatchewan sub-basin, to 46.4% in the rugged mountainous Cline River sub-basin (E.R.F.C.B., 1969). Approximately 50% of the land surface of the Cline and Upper Saskatchewan sub-basins have a slope gradient exceeding 40%, while in the lower elevations of the Middle Saskatchewan sub-basin, only 26% of the land surface has a slope gradient greater than 40% (E.R.F.C.B., 1969).

These slope data reflect a rugged topography with a sharp environmental gradient being produced by the elevational variations. This has resulted in considerable micro-climatic variations within different areas of the basin and has in turn resulted in considerable variations in soil development and subsequent vegetation patterns throughout the area. This high degree of variation also influences slope/run-off relationships within the Basin. Topographic variation also results in considerable limitations for development of park facilities and also results in erosion problems, when the surface vegetative cover is disturbed by land use. On this basis, watershed protection problems are likely to arise in the event of fire or other natural phenomena, or from the removal of vegetation on slope areas. The implications of relief patterns, in terms of watershed conditions and soil and vegetation relationships, are discussed in detail in Chapter 4.

2.3.3 Soils

Soil development can vary considerably over any mountainous area. Micro-site variations in surface materials, modified locally by differences in parent materials, climate, vegetation, slope, drainage and time are primarily responsible for these differences. Other factors such as land use (e.g. grazing, trail use, etc.) can also have a considerable, modifying effect, on a local basis. This situation is characteristic of the upper North Saskatchewan basin. In highly generalized terms, the mountainous topography, consisting of steep slopes and deep valleys, was developed on uplifted Mesozoic shales and sandstones, with some local Cambrian limestones occurring sporadically (Rowe, 1974). The derived residual and glacial surface materials are variable in texture and composition and are influenced by a wide range of micro-climatic conditions (Pettapiece, 1971). On this basis, soil development has been extremely variable (Pettapiece, 1971).

As a general rule, soil patterns reflect elevational change. Areas of high elevation above 2,100m, consist mainly of exposed bedrock outcrops, with colluvial deposits of talus blanketing the lower slopes (Pettapiece, 1971). Soil formation at the higher elevations is very limited and vegetation is generally absent. Lower slopes generally have good soil development, although soil depths are usually shallow and horizons are poorly developed. Coniferous stands are generally well-established on these slopes and in many areas, climax stands are evident. Soil has generally developed from parent materials consisting of till deposits or in some areas, till overlain by colluvium (Pettapiece, 1971). Thin soils (lithic subgroups) and shallow humo-ferric podzols occur most frequently, with eutric and dystric brunisol profiles occurring sporadically (Rowe, 1974). Soil development on glacial outwash and alluvial fan deposits tends to be poor and this factor is reflected in the poor dvelopment of vegetation on these sites (Wallis and Wershler, 1981; Pettapiece, 1971).

The loess deposits along the North Saskatchewan River Valley are of varying thickness (Pettapiece, 1971). These deposits have a relatively high infiltration capacity, but are highly susceptible to aeolian and fluvial erosion, especially if the vegetative cover is not well-established (Wallis and Wershler, 1981). This can be a particular problem on some exposed slopes. In general, most soils have a low erosion hazard in cases where vegetation is well-established, but there could be serious erosion and stream sedimentation problems in cases of ground disturbance and vegetation removal, especially in loess and clay soils (Pettapiece, 1971; E.R.F.C.B., 1969). Silty, alluvial, floodplain deposits and highly organic muskeg type soils are also highly sensitive to disturbance. These are loosely consolidated and unstable materials and stream siltation is a potential problem in areas containing these soil types (Pettapiece, 1971).

2.4 Climate

Climatic data for mountainous areas such as the upper North Saskatchewan Basin are generally poor. These records usually reflect very localized climatic conditions, at lower elevations, in valley locations. Therefore, the available climatic information cannot be considered as being representative of the entire area.

For example, the only weather station making continuous observations is located at Nordegg, which is at a lower elevation than any part of the study area. Consequently, records from this station do not adequately reflect the climatic patterns of the upper North Saskatchewan Basin. Seasonal records of daily precipitation and temperature are recorded at the Cline fire tower. The Eastern Rockies Forest Conservation Board installed 23 storage gauges in or adjacent to the study area, during the 1960's. Few of these gauges are currently in operation. However, with this small network of gauges, data recorded cannot be considered as representative of the area, due to its size and micro-climatic variables. The only other regular weather stations in the vicinity of the study area, which might be applicable are Jasper, Banff, and Lake Louise. Partial observations are also recorded at the Parks Canada warden station in the Saskatchewan Crossing area. However, local micro-climatic patterns would limit the accuracy of extrapolating this climatic data to the study area on a general basis.

In general terms, the upper North Saskatchewan Basin has a cold, sub-humid climate with a relatively short growing season (Janz and Storr, 1977). It should be noted however, that generalities can be very misleading when applied to mountainous areas, due to the potential for extreme climatic variability over relatively short distances. Meso and micro climatic variations are produced by the interrelationship between elevation and aspect, with factors such as wind and rainshadow effects being of considerable importance (Pettapiece, 1971).

The precipitation, temperature and wind regimes that are determined generally by latitude, are modified considerably by the topography of the basin. Generally the climatic pattern is based on elevation. Increasing elevation is generally associated with increasing wind velocities and considerable increases in precipitation, along with a notable decrease in temperature (McKay, Curry, and Mann, 1963; Janz and Storr, 1977).

Micro-climatic variations are considerable within the study area, due to variations in both relief and topography, and the influence of prevailing winds upon these factors. Two specific areas illustrate the extreme cases; 1) the Kootenay Plains, 2) Pinto Lake.

The North Saskatchewan River valley downstream from Whirlpool Point including the Kootenay Plains has a very unique climate for a mountain environment. In general terms, the winter months are considerably milder and summer months are notably dry, largely due to the effects of prevailing winds blowing down the North Saskatchewan River Valley. This portion of the valley also lies in a rain shadow from the west and east and therefore, receives much less precipitation than the mountain slope areas. The valley area must be considered as semi-arid, due to low precipitation, yet only a few kilometres away, in more elevated areas, there is permanent snow cover with temperatures rising above freezing only during the warmest summer months.

Storage gauge records maintained by the E.R.F.C.B. for a ten year period, indicate that average annual precipitation for the Kootenay Plains area is 35.8 cm while at Pinto Lake, which is 32km away but 458m higher, the average annual precipitation is 73 cm (E.R.F.C.B., 1969). Winter precipitation on the Kootenay Plains is also relatively low, with 36% of the total precipitation falling as snow. Over 60% of annual precipitation falls as snow in the Pinto Lake area (E.R.F.C.B., 1969). Although precipitation is estimated at 75 cm or more in higher elevation areas, it is likely that considerably greater amounts of precipitation fall in the high elevation areas above 2,000 m. The mountainous Cline and Siffleur areas, which contain snow fields, are characteristic of these high elevation sites. It is estimated that precipitation at elevations exceeding 3,000 m may be as high as 125 cm (water equivalent) (E.R.F.C.B., 1969; McKay, Curry and Mann, 1963). This high country is also much colder and more humid than the Kootenay Plains and lower valley slopes.

The mean maximum temperature in the upper North Saskatchewan Basin varies considerably with summer highs in excess of 30°C and winter lows ranging down to -40°C (Janz and Storr, 1977). The valley area climate is more moderate, with considerably less annual and diurnal temperature fluctuations, due to the relatively high frequency of chinook winds.

At elevations above 2000m the mean annual temperature is roughly +5°C, with a mean maximum of +30°C, and a mean minimum of -40°C (Janz and Storr, 1977). However, summer temperatures of +30°C would be very uncommon and temperatures above +25°C would occur infrequently. Winter temperatures are generally below 0 and heavy snowfall usually occurs.

The variation in temperature with elevation is also modified further by aspect. On a very localized basis, aspect is probably the most important factor influencing micro-climate, producing marked differences in temperature regimes between north-facing and south-facing slopes (Pettapiece, 1971). Aspect affects insulation and influences evaporation. Therefore, aspect plays a major role in determining the humidity of a site (Janz and Storr, 1977). This also has a considerable influence on soil formation and subsequent development of vegetation patterns within the basin (Pettapiece, 1971; Janz and Storr, 1977).

2.5 Vegetation

In highly generalized terms, vegetation patterns within the study area can be broken down into two basic types using the classification developed by Rowe (1972). These types are referred to as the Upper Foothills unit and the East Slope Rockies unit (See Plate 2).

The Foothills Unit is characterized by the vegetation pattern found in the extreme eastern portion of the study area. Basically, lodgepole pine (Pinus contorta) is predominant with white spruce (Picea glauca) being co-dominant. Mixed wood stands occur infrequently and Alpine fir (Abies lasiocarpa) is sporadic in occurrence (Rowe, 1972).

The East Slope-Rockies Unit is characterized by the presence of the Engelmann spruce (Picea engelmanni) and White Spruce hybrid (Picea glauca) complex and at somewhat higher elevations (greater than 1830 m) by Engelmann spruce (Picea engelmanni) alone (Rowe, 1972). Recent fires in portions of the basin have resulted in the dominance of lodgepole pine (Pinus contorta) over much of the area (Cormack, 1953). This has been largely due to the prolific regeneration capability of this species (Cormack, 1953). With increasing elevation on slopes, alpine fir (Abies lasiocarpa) becomes more prevalent, due to the ability of this species to exist under harsh site conditions (Rowe, 1972).

There are considerable micro-climatic and topographical variations which have resulted in a number of distinct plant communities within the overall context of the general vegetation pattern (Wallis and Wershler, 1981). For example, the extremely coarse deposits adjacent to mountain stream courses are covered by an almost solid mat of dryas (Dryas drumondii) (Pettapiece, 1971). Prairie vegetation is present over a significant portion of the North Saskatchewan River Valley along the valley floor and lower alluvial fan sites (Pettapiece, 1971). This vegetation pattern generally occurs within 15 to 30 m above river level, extending roughly from Whirlpool point to the Whitegoat Creek fan. The largest areas of prairie

Plate 2: North Saskatchewan River Valley (looking northeast from Highway 11, near the turn off to the Bighorn Damsite).

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This plate illustrates the considerable range in vegetation found within the basin, and depicts the changes in vegetation patterns with increasing elevation. The valley grasslands rise into a mixed-wood forest, which becomes a climax coniferous forest, a few hundred meters from the valley floor. Stand density decreases with elevation above 1800m and alpine meadows and bare rock become dominant at the highest elevations.

vegetation are found on the Whiterabbit Creek fan and the fan opposite the Siffleur River confluence, which together comprise the Kootenay Plains (McPherson, 1970).

The semi-arid North Saskatchewan River Valley in the Kootenay Plains area, consists of open grassland with scattered clones of Aspen (Populus tremuloides) and some sporadic Douglas fir (Pseudotsuga menziesii). An abundance of pussy toes (Antennaria spp.) and sage (Artemisia spp.) combined with about 40% bare ground surface between the plants and evidence of heavily over-browsed shrubs indicates that the grassland is overgrazed (Landals, 1973). Moderately arid sites on exposed ridges and slopes along the North Saskatchewan River Valley, are dominated by limber pine (Pinus flexilus) which is well adapted to xeric site conditions found on the exposed slope areas (Pettapiece, 1971).

Alluvial fan sites throughout most of the basin are dominated by aspen (Populus tremuloides) with balsam poplar (Populus balsamifera) being relatively abundant in more mesic sites where the water table is near the surface. Black spruce (Picea mariana) is dominant in poorly drained and low lying areas along stream courses and on the outer margins of floodplains in the main valleys, such as the North Saskatchewan and the Cline. Various riparian species such as willows (Salix spp.) and birch (Betula spp.) are relatively abundant in these low lying, poorly drained areas. These species are an important source of browse for ungulates.

At treeline, and on exposed ridges at higher elevations, a grass-meadow vegetation pattern is evident. Juniper (Juniperus spp.) becomes very prevalent at higher elevations as well as shrubby cinquefoil (Potentilla fruiticosa) and numerous species of alpine flowering herbs (Pettapiece, 1971). The vegetation patterns around the Cline Pass are typical of areas above the treeline. Vegetation is characterized by small, isolated stands of stunted alpine fir (Abies lasiocarpa), surrounded by open alpine meadows. These meadows are dominated by mountain heathers (Phyllodoce spp. and Cassiope spp.) and by numerous herbaceous plants (Landals, 1973).

Bedrock slopes and bare rock-colluvium slopes are found above the meadow areas. Some of these slopes have permanent snow cover (e.g. Mount Cline) and most of these areas are essentially devoid of vegetation, due to poor site conditions and limited soil development. The relationship of vegetation to runoff and variations in vegetation within different watershed zones is outlined in detail in Chapter 4.

2.6 Water Balance

The water balance is a function of the complex interaction of variables such as climate topography, soil and vegetation. In mountainous regions, there is generally high runoff, due to cool climate and low potential evapotranspiration. The existence of large areas of exposed bedrock and colluvial deposits with relatively low permiability, combined with high slope gradients is conducive to both high volumes of runoff and generally flashy runoff response.

The total runoff is a function of precipitation, minus water lost through evapotranspiration. Regime will be affected by changes in soil moisture, groundwater, surface detention (e.g. snow) and storage change. Water balance data calculated for the Basin by the E.R.F.C.B., indicate that precipitation amounted to 1,492,538 acre-feet[2] over an area of 228,571 hectares or 78cm (E.R.F.C.B., 1969). The water yield or net discharge at the Tershishner gauge was calculated to be 49.8cm. Therefore, evapotranspiration loss is 78 - 49.8 = 28.2cm (E.R.F.C.B., 1969). This relatively low evapotranspiration figure could be the result of a combination of large bedrock and colluvial areas above 2100m, which are essentially devoid of vegetation, and which account for roughly 50% of the basin area (E.R.F.C.B., 1969). The high concentration of runoff in the spring and early summer snowmelt period is also a very important factor.

Water balance variations between sub-basins and even between high and low elevation areas of the same sub-basin, can be considerable. Therefore, water balance equations should be completed for local sites, for management purposes. However, water balance equations cannot be accurately developed, due to the lack of detailed precipitation and runoff data. However, a hypothetical example might be developed for Pinto Lake and Cline River to illustrate potential variations in water balance in different areas of the Basin.

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[2] The term acre-feet is used in this thesis as a measure of streamflow, as this is still the accepted measure and no appropriate metric equivalent has been developed.

PpT = (P.E. - D) + Surplus +/- Storage Change

Pinto Lake (rock) 40 = (13 - 8) + 35 +/- 0 (Average)

Cline River (forest) 20 = (18 - 3) + 5 +/- 0 (Average)

On this basis, the Pinto Lake area would have more water available for runoff than the Cline River area, due to greater precipitation and lower potential evapotranspiration, combined with lower detention storage, due to the greater area of exposed rock surface. The presence or absence of vegetative cover can significantly alter the volume and timing of runoff. The presence of wetlands in a basin could also be a significant factor in soil moisture retention at the Cline River site. Surface detention is a major factor which varies with vegetation and topographical factors. Base flow in mountain watersheds is usually minimal. However, base flow may be important locally, in colluvial or drift/alluvial sites (Laycock, 1957a). The flashy runoff from bare rock surfaces is modified directly and/or balanced by slow releases from these deposits, including melt releases from colluvium (Laycock, 1957a). The combination of these and other factors affects water balance locally. Water balance equations for specific areas of the study area are described in chapter 4.

2.7 Hydrology

2.7.1 Water Resources

The North Saskatchewan River drains an area within Banff National Park and the area between the Banff National Park boundary and the Bighorn Dam (study area). The drainage density within the study area of approximately 3km of streamcourse per km^2 indicates that this basin is well-drained by numerous tributary streams of various orders (E.R.F.C.B., 1969). The major tributaries include the Cline and Siffleur Rivers and Whiterabbit Creek (See Plate 3).

Streams within the basin are characterized by relatively steep stream gradients, due to the abrupt changes in relief. For example, Whiterabbit Creek drops an average of 30.4 m over each km of stream course and the Cline River also drops rapidly, with an average drop of 15.8 m per km of stream course (E.R.F.C.B., 1969).

The surface area of lakes within the basin is very small, totalling some 978 hectares, which is less than one percent of the total basin area. All lakes within the basin are small and relatively shallow, with many lakes existing as potholes in the outwash or till deposits of the North Saskatchewan Valley (See Plate 5). The remaining lakes are small, high-elevation cirque lakes, dammed by moraine and rock deposits.

2.7.2 Streamflow and Water Yields

The precipitation/runoff relationships have not been extensively studied in the individual sub-basins, partially due to the considerable variations in micro climate and topographical conditions, which make accurate measurement difficult. Detailed streamflow information for the study area and particularly for the tributary streams is not available, due to the absence of any extensive stream gauging network. All streamflow information for the Basin is recorded by four stream gauges at the following locations:

North Saskatchewan River at Saskatchewan Crossing (Banff, N.P.)
Mistaya River near Saskatchewan Crossing
North Saskatchewan River below Tershishner Creek
North Saskatchewan River near Saunders

All recording stations, with the exception of Saunders provide only seasonal records during the May to October period. The gauges measure streamflow from different types of watersheds. For example, the combined basins of the Mistaya and North Saskatchewan above Saskatchewan Crossing are comprised of high country near the continental divide, which

Plate 3: The Cline River

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The Cline River is characteristic of the fast moving major tributary streams. The broad glacial valley is also characteristic of the major tributaries. This provides a sharp contrast to the third order streams, which are of fluvial origin, as shown below.

Plate 4: Unnamed Tributary of the Cline River

Plate 5: White Goat Lakes

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Images en couleur

The White Goat lakes, located adjacent to Highway 11 near Cline River, are typical of the small lakes found in the lower elevation areas of the Basin. Lakes in this area are generally small and very shallow. Lakes at higher elevations are generally deeper, and are more productive fish habitat, due to higher water quality.

includes extensive glaciers and snow fields. The basin above Tershishner Creek is largely comprised of front ranges. Because of these considerable environmental differences and subsequent differences in runoff patterns, this streamflow information is not totally representative of the runoff patterns in the study area. Streamflow measurements for individual tributary streams are not presently recorded, however this information would be desirable for watershed management purposes.

2.7.3 Streamflow Regime and Water Quality

The timing of run-off within the individual basins of the study area is difficult to measure, largely because the only stream gauging stations are on the North Saskatchewan River. However, estimates provide a relatively accurate alternative. Of the discharge recorded at Tershishner, only about 57% originates upstream from the Forest Reserve boundary (E.R.F.C.B., 1969). Therefore, the data from the gauges and subsequent hydrographs are not representative of the North Saskatchewan River at that point.

The maximum instantaneous discharge of $566.34m^3/sec.$ occurred on July 9, 1965 and the minimum daily discharge of $7.36m^3/sec.$ was recorded on March 1, 1954 (estimated under ice conditions) (E.R.F.C.B., 1969). Peak runoff occurs in July and June and August flows are almost as high. Late summer flows remain moderate in the North Saskatchewan and this flow is relatively well sustained in the winter months, especially by the drawdown of Abraham Lake. Meltwater from the glaciers and snow fields contributes to the spring and early summer flows and is stored for discharge during the winter low flow period.

Water quality in the North Saskatchewan River and all tributary streams could be regarded as 'good' at the present time. These conditions have largely resulted due to the absence of intensive land use adjacent to stream channels and the absence of sewage disposal into streams. The small lakes in the study area are also of good quality at the higher elevations. Landslide Lake and Pinto Lake are also regarded as having a good recreational fishing potential.

2.7.4 Water Use and Demand Patterns

The study area serves as an important water source for the North Saskatchewan River. Streamflow is considerable at the point where the river enters the study area from Banff National Park, with a mean flow (May to October) of 1,124,000 acre-feet (E.R.F.C.B., 1969). The study area contributes an additional 846,000 acre-feet to the River between Banff National Park and the Bighorn Dam (E.R.F.C.B., 1969).

Water resource developments for hydro power production at Bighorn, and ever increasing downstream demands, place considerable importance on streamflow rising or passing through this basin. The different types and patterns of water demand within and outside this region, as well as possibilities of watershed damage and opportunities for improvement through management, must therefore be given careful consideration in any watershed development proposals.

The North Saskatchewan River provides water supply and waste disposal for Rocky Mountain House, Drayton Valley, Devon, Edmonton, Fort Saskatchewan, St. Paul and several cities and towns in Saskatchewan. As these demands are increasing constantly, watershed management is necessary to ensure that these demands can be met in the long term. To date however, watershed management has been totally oriented toward structural control works for streamflow regulation, to enhance regime for hydro power production and related downstream water demands.

In order to generate hydro-electric power and improve streamflow in the winter low flow periods, the Bighorn Dam was constructed and became operational in 1972 (See Plates 6,7 and 8). The dam was constructed by TransAlta Utilities, with major subsidies from the Province of Alberta. The Bighorn Dam project was partially justified on the basis of P.R.I.M.E., with some water from the reservoir originally intended for diversion to supplement the flow of the South Saskatchewan River, where it is badly needed for irrigation and domestic purposes. The increased streamflow, especially in the fall and winter months, is crucial for pollution abatement downstream. Waste from the pulp mill at Prince Albert is

Plate 6: The Bighorn Dam

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A portion of the Bighorn Dam, looking eastward from the lookout point near Highway 11. The reservoir is shown at full supply level. Control works and the power plant are located directly below the dam.

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Plate 7: Flow Control Spillway

This is a flow control site, located near Highway 11, approximately 2.5 km east of the Bighorn Dam, on the extreme eastern point of Abraham Lake. A roadway (shown below) crosses this control dam and leads to the Bighorn Dam site.

Plate 8: Road Across Spillway Control Dam

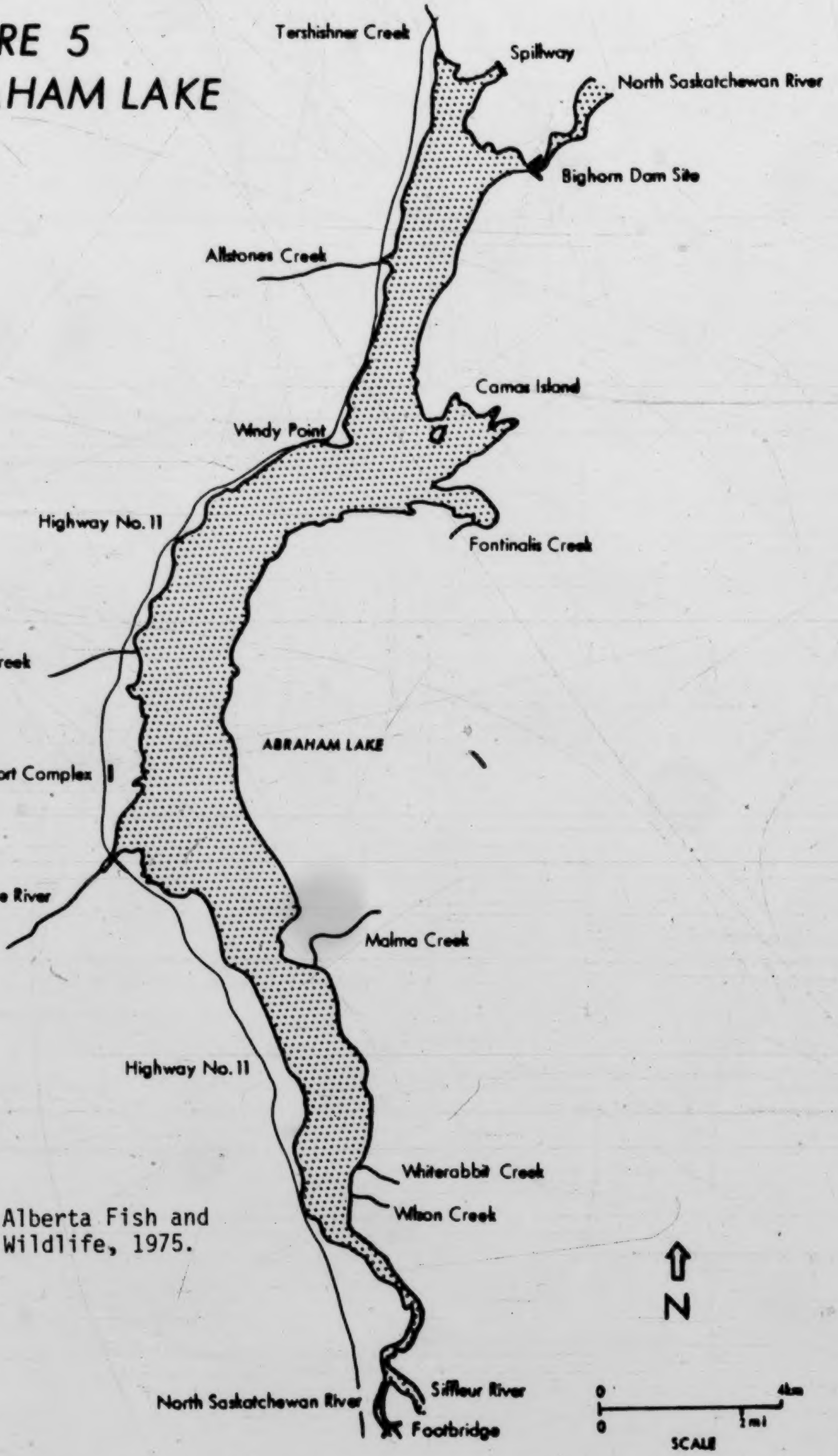
disposed of in the North Saskatchewan River and a pulp mill at Rocky Mountain House is also presently under consideration. Such developments could place additional demands on the North Saskatchewan River for pollution abatement purposes.

The Bighorn Dam reservoir (Abraham Lake) has a live storage capacity of roughly 1,165,000 acre-feet, and covers approximately 35km^2 (See Figure 5; Plates 9 and 10). Water storage, accumulated from spring and early summer flow, serves to augment low winter flows using the Bighorn hydro-electric plant to control the discharge (Calgary Power, 1973; E.R.F.C.B., 1969). Access to power plants, water intakes, pumphouses and sub-stations is limited for reasons of public safety, but this use should not preclude other uses of the reservoir which are complementary to the prime purpose of the developments; steamflow argumentation during the low water season and production of hydro-electric power (Calgary Power, 1973). However, the reservoir level fluctuates some 60m and this has had a considerable impact on the reservoir shoreline and on the potential for other uses (Frechette, 1970; E.R.F.C.B., 1969).

TransAlta Utilities is considering changes in the operation of the Bighorn Dam for "power peaking" purposes, to compensate for the rapid surges in power demand occurring in the winter months and thereby increase the efficiency of power production (Alberta Environment, 1983). However, this proposal would require increased winter drawdown of the reservoir and could possibly require additional on-stream storage.

The Water Resources Branch of the Department of Agriculture surveyed four other potential dam sites in the study area, in 1964. These sites have a combined potential storage capacity of over 500,000 acre-feet and could serve to supplement storage at Bighorn. These potential sites are Whirlpool, located at the mouth of Spreading Creek (368,300 acre-feet), Coral Creek (15,700 acre-feet), Cataract Creek (64,600 acre-feet) and Cline River (136,000 acre-feet) (Alberta Department of Agriculture, 1964). The latter three sites are located in the White Goat Wilderness Area, while the Whirlpool site is located near the north boundary of the Siffleur Wilderness Area.

FIGURE 5
ABRAHAM LAKE


Tershishner Creek
Spillway
North Saskatchewan River
Bighorn Dam Site
Allstones Creek
Camas Island
Windy Point
Highway No. 11
Fontinalis Creek
White Goat Creek
ABRAHAM LAKE
Resort Complex
Cline River
Malma Creek
Highway No. 11
Whiterabbit Creek
Wilson Creek
N
Siffleur River
North Saskatchewan River
Footbridge
0
4km
0
2mi
SCALE

Source: Alberta Fish and Wildlife, 1975.

Plate 9: Abraham Lake Reservoir (looking south)

Abraham Lake reservoir looking upstream from the Bighorn Dam viewpoint. The reservoir looking north from the eastern edge of the Kootenay Plains is shown below:

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Plate 10: Abraham Lake Reservoir (looking north).

3. Historical Review of Land Use Policies in the East Slopes

3.1 General Background

A wide range of biophysical inventories, resource assessments, land capability mapping exercises and resource management studies have been completed for the upper North Saskatchewan Basin. These studies have largely been completed by various government agencies and most have been designed to fulfill a single research objective (e.g. determine land capability for outdoor recreation). In recent years, an integrated management approach to multiple resource use has been utilized. However, in this "multiple-use" approach, there is often a failure to consider more than one resource use for a given area and large land units are broken down into small units, each having a single use. A major problem inherent in this approach is that potential conflicts between individual uses, in a multiple-use situation, have not been considered. For this reason, a high degree of resource integration has not been accomplished and consequently, resource planning is still highly single-use oriented.

3.2 Resource Inventory and Assessment Studies

A considerable amount of resource inventory, assessment and mapping work has been completed for the study area and for the East Slopes Region in general. McPherson (1970) completed investigations into the glacial history and landforms of the upper North Saskatchewan River Valley. Pettapiece (1971) completed reconnaisance soil surveys which provided detailed soil information for large areas of the upper North Saskatchewan River Valley. Surficial geology, erosion potential and slope maps (1:50,000) were also prepared by the Alberta Research Council (1974). A series of forest inventory programs describing forest density, height, species, age composition and site quality have been conducted on an on-going basis (Alberta Energy and Natural Resources, 1981). Forage inventories have also been completed and maps prepared (1:50,000) for the study area and for all public lands in Alberta (Alberta Energy and Natural Resources, 1982). These inventories provide an assessment of natural vegetation and serve to identify opportunities for supporting both domestic animals and wildlife (Alberta Energy and Natural Resources, 1982).

A physical land classification mapping program has also been initiated for the study area. This program involves the preparation of maps displaying genetic composition (landform and parent geological material), surface expression, texture, slope and aspect and the integration of soil classification and drainage information (Alberta Energy and Natural Resources, 1977). These maps are intended to provide a physical resource data base for resource management and planning. Land capability for outdoor recreation (and other land uses) was evaluated and mapped as part of the Canada Land Inventory (C.L.I.) and Alberta Land Inventory (A.L.I.) programs. Seven classes of land are differentiated on the basis of either the intensity of outdoor recreational use or on the capability of a given land unit to sustain recreational use (Alberta Energy and Natural Resources, 1982).

Integrated management planning projects have also been initiated for the study area. These planning projects are designed to provide comprehensive regional land use plans and integrated resource management plans for specific sub-regions (Alberta Energy and Natural Resources, 1980.) In addition, integrated resource plans have been initiated for specific problem areas (Alberta Energy and Natural Resources, 1980). The Rocky-Clearwater Management Overview, recently completed, provides a regional land use plan for the study area and is reviewed in detail in Section 3.3.5. Two sub-regional land use plans have also been initiated for the Bighorn-Kootenay Plains area and the Rocky-North Saskatchewan area, in the Rocky-Clearwater region (Alberta Energy and Natural Resources, 1982). Work has also been initiated on the development of a comprehensive river basin study for the North Saskatchewan Basin (Alberta Environment, 1982). This study will be directed towards the development of a framework designed to establish the strategies and priorities for water resource development, control and protection (Alberta Environment, 1982). This study may also be directed towards investigating the feasibility of major water resource management projects, including the potential for inter-basin transfer (Alberta Environment, 1982).

3.3 Watershed Research and Management

Although a considerable amount of environmental research has been completed for the upper North Saskatchewan Basin, very little directed research has been initiated relative to watershed management. The importance of watershed is generally recognized in the resource capability and integrated management oriented literature, but it is generally assumed that watershed is totally compatible with all non-extractive resource uses (E.R.F.C.B., 1969; E.C.A., 1972; Alberta Government, 1977). This lack of recognition is due largely to the fact that the term "watershed" is not well defined. Similarly, watershed management objectives and ideal watershed conditions required to meet each objective are never fully considered in the literature. In addition, potential use conflicts between watershed and other uses have not been described to any extent. The degree of conflict possible between other resource uses and the different watershed management objectives has also not been given adequate consideration. These deficiencies are evident in the traditional orientation of watershed research and management programs and are also evident in resource capability assessments and in the present policy and watershed management plans.

3.3.1 Eastern Rockies Forest Conservation Board

The Eastern Rockies Forest Conservation Board was formed jointly by the Governments of Canada and Alberta in 1947, to manage the Rocky Mountain Forest Reserve, which included the East Slopes region of Alberta. The E.R.F.C.B. was established for the purpose of conserving, developing, maintaining and managing the forest resources within the East Slopes to obtain the greatest possible flow in the Saskatchewan River and its tributaries (Hanson, 1973). The Eastern Rockies Forest Conservation Act implied that water was the most important product of the forest zone and consequently, watershed management was to be the immediate and primary concern of the E.R.F.C.B. (Hanson, 1973; E.C.A., 1972). The E.R.F.C.B. recognized at a relatively early stage, that through time, watershed management and improvement could be attained simultaneously with other resource uses, providing that adequate resource management guidelines were established (E.R.F.C.B., 1969). The E.R.F.C.B. also recognized the importance of the East Slopes region as a water producing area, based on the nature and extent of downstream demands and recognition of the need to provide effective management, to ensure the maintenance and improvement of water supplies in perpetuity (E.R.F.C.B., 1969). On this basis, the E.R.F.C.B. believed that more water would be required and therefore, stream yield improvements were desirable.

By 1963, the broad management objectives of the E.R.F.C.B. incorporated three major themes (Hanson, 1973; E.C.A., 1972; E.R.F.C.B., 1969; 1963):

1. Conservation of the watershed values of the East Slopes involving:
    a. protection of the resources
    b. restoration where damage had occurred, and
    c. improvement over pristine conditions.
2. Full use on a sustained yield basis, of all renewable resources under multiple-use management, consistent with watershed conservation practices.
3. Non-renewable resources used under controls so as to protect the watershed and other forest resources.

These objectives indicate that enhancement of the natural watershed conditions is possible through watershed management. Secondly, there is recognition of the fact that other resource uses are potentially detrimental to "watershed condition" and therefore, management is required. However, despite this recognition, these objectives as stated tend to be conflicting. For example, conservation of the watershed values of the East Slopes, to maximize resource protection and to ensure restoration of damaged watersheds, may not provide sustained yields for all other renewable resources. For example, if improvement in water yields is desirable, complete vegetation removal over major portions of drainage basins within the East Slopes, would be the most effective management strategy (Laycock, 1965). However, implementation of such a strategy would do very little relative to "conserving watershed values" (Laycock, 1965).

A second major problem inherent in the E.R.F.C.B. objectives is that terms such as "watershed", "watershed values" and "watershed damage" were never adequately defined. For example, "watershed damage" may occur if large areas are logged over. However, this type of watershed damage is required, if improvement in water yields is the objective to be emphasized, since removal of vegetation is necessary to reduce transpiration losses and thereby increase the amount of water available for runoff (Laycock, 1965; Ward, 1972). These deficiences are also evident in the E.R.F.C.B. basin specific reports as well.

"Conservation Unit Guide R-6", prepared for the upper North Saskatchewan Basin in 1969, contains a fairly detailed assessment of watershed conditions. In this report, some watershed damage was noted in some areas of the basin and some opportunities for improvement were evaluated (E.R.F.C.B., 1969). Two primary resource uses were recognized for the upper North Saskatchewan Conservation Unit by the E.R.F.C.B.; outdoor recreation and watershed (E.R.F.C.B., 1969). Outdoor recreation was limited to extensive activities such as trail riding, mountain climbing, hunting and fishing, which were deemed to have no impact on "watershed values." (E.R.F.C.B., 1969). Therefore, watershed and outdoor recreation were assumed to be compatible uses. Although recreational access to this area was relatively poor in 1969, some deterioration of "watershed conditions" was noted. This damage was apparently caused by random, uncontrolled, recreational use (E.R.F.C.B., 1969). The E.R.F.C.B. also recognized that with improved access, a considerable increase in recreational use and subsequent facility development was inevitable, due to the high aesthetic qualities of this area (E.R.F.C.B., 1969). Therefore, the E.R.F.C.B.'s assumption that recreation and watershed are totally compatible activities did not hold true. Although recreation is currently recognized as a major resource use for this area, very little consideration has been given to the potential impact of recreation on the watershed (Foothills Resource Allocation Study, 1973; E.C.A., 1973; Alberta Government, 1972; 1977). In addition, potential strategies for managing the existing levels of recreational use, to reduce impacts on watershed conditions, were apparently not considered. A second major deficiency in the management approach of the E.R.F.C.B., was a failure to consider how the watershed environment might respond to management. The E.R.F.C.B. recognized the need for such measures as erosion control, site rehabilitation and the protection of stream courses, for the protection of both watershed and recreational values (E.R.F.C.B., 1969). On this basis, regime and water quality were acknowledged as being important components of streamflow within the upper North Saskatchewan Basin. The function and importance of different areas within the basin, relative to runoff and some consideration of the management emphasis for each area, were noted in very general terms. Despite recognition of the importance of regime and water quality, considerable emphasis was placed upon the objective of yield improvements (Golding, 1973; E.R.F.C.B., 1969; Jeffrey, 1964). The objective of "obtaining the greatest possible flow in the Saskatchewan River and its tributaries" certainly reinforces this management emphasis (E.R.F.C.B., 1969; E.R.F.C.B., 1947).

Despite the recognition of yield improvement as the major watershed management objective for the North Saskatchewan Basin and for the entire East Slopes region, no methodology for the attainment of yield improvements or outline of any possible management techniques was ever developed. Similarly, the implications of watershed management for yield improvement upon the regime and water quality components of streamflow, were also not identified. In the Conservation Unit Guide, management emphasis was also placed upon watershed protection and the restoration of watershed conditions, with considerable detail on how these measures are complimentary to recreation, wildlife habitat and environmental preservation (E.R.F.C.B., 1969). However, the fact that protection and restoration may produce the opposite conditions to those required to increase water yields, was ignored. Vegetation enhancement, accomplished through a high degree of watershed protection, is in direct conflict with the stated objective of yield improvement (Swanson, 1973; Satterlund, 1972; Hibbert, 1967).

Laycock (1965) indicated that if yield improvements were desirable, the watershed management techniques required to achieve this objective, would emphasize large-scale removal of vegetation within the basin. Alternatively, if regime and water quality improvements were desirable, the required management techniques would emphasize a high degree of watershed protection, to maintain dense, healthy vegetation cover (Laycock, 1965; Croft and Bailey, 1964). However, this degree of vegetation maintenance would increase transpiration losses and thereby reduce the amount of water available for runoff (Ward, 1972; Laycock, 1965). Therefore, it would not be possible to obtain increased water yields by providing a high degree of watershed protection. On this basis, the objectives of the E.R.F.C.B. tend to be mutually exclusive. This conflict of objectives is the major deficiency in the management approach adopted by the E.R.F.C.B. and on this basis, realistic watershed management objectives were never adequately defined.

A second major deficiency in the E.R.F.C.B.'s approach to watershed management was the generalized application of a single objective (yield improvement) to all basins within the East Slopes region. Inherent in this approach is a failure to recognize the very considerable differences between individual basins, in terms of existing watershed conditions, variations in upstream and downstream water demand and use patterns, the adequacy of existing watershed/streamflow conditions relative to these demand patterns and the differing opportunities for improving upon natural watershed conditions in each basin. This orientation must also be based on the assumption that yield improvements are desirable in all East Slopes basins. However, an assessment of water supply, as related to downstream demand patterns indicates that additional water is not as urgently required in most East Slopes basins, as is a better seasonal distribution of the existing streamflow (Laycock, 1973; 1957a).

Within most East Slopes basins, opportunities for yield improvement are very limited, in relation to the potential for improvements in water quality and in regime (Laycock, 1973). For example, the E.R.F.C.B. researchers noted several disturbed sites in the upper North Saskatchewan Basin and recommended restoration (E.R.F.C.B., 1969). However, as forests mature and these disturbed sites recover, yields will diminish somewhat, due to the increase in transpiration losses produced by this mature vegetation, but this will result in a better seasonal distribution of the flow (Laycock, 1965). This improvement in regime is needed in the upper North Saskatchewan Basin, relative to the nature, extent and patterns of downstream water demand. However, management for regime improvement compromises the E.R.F.C.B.'s stated objective of yield improvement. Therefore, it can be said that the E.R.F.C.B.'s management orientation and objectives do not reflect actual water demands or opportunities for improvement within the upper North Saskatchewan Basin.

The lack of well-defined watershed management objectives could be partially based upon a lack of management information. Although the general concepts of watershed management were well entrenched in the E.R.F.C.B.'s management objectives, practical information to substantiate the extent to which the various management objectives could be realized and a methodology for assessing the environmental implications of emphasizing a single watershed management objective, were not in place. It is also apparent that the emphasis at this point in time, was on increasing actual water supply, in response to increased demand. Modification of the timing of supply to achieve an improved supply versus demand situation, was not apparently considered as a viable alternative. It is possible that the short-term effect of better watershed management may have been recognized as having minor benefits, and this was subordinated in relation to other objectives.

During the early years of the E.R.F.C.B. it was generally believed that more water was required. (Swanson, 1977; Jeffrey, 1964; E.R.F.C.B., 1947). Also at this time, it was anticipated that yield improvements in the order of 25% could be achieved in all East Slopes basins, through a program of intensive carefully planned forest management. Results of numerous small basin studies being carried out in Colorado, provided the basis for this optimism. Due to the apparent physiographic and climatic similarity between the Colorado Rockies and Alberta's East Slopes, the potential for yield increases in Alberta was believed to be high (Swanson, 1977; Jeffrey, 1964). However, this degree of yield improvement could only be accomplished through extreme measures (e.g. extensive clearcutting) and therefore was of questionable viability.

Early experiments in Colorado, such as the Fool Creek and Wagon Wheel Gap Experimental Watershed programs, produced results which clearly demonstrated that significant yield improvements could be achieved through manipulative treatment in forested sub-alpine watersheds (Leaf, 1975; Ward, 1971; Bates and Henry, 1928). However, the main barrier to practical application, was a complete lack of scientific information regarding the hydrometeorological and hydrological aspects of the East Slopes environment, and a lack of forest management techniques that could be realistically applied to a large basin. As a result, the Alberta Watershed Research Program was developed specifically to alleviate these information gaps and to develop the necessary techniques to increase yields (Swanson, 1977). The results obtained from this program, since its inception in 1959, have been inconclusive (Neill, 1980). Although some yield improvements were noted, practical application of such a program on a large scale could severely limit recreational and other activities and cause considerable environmental damage. This damage would produce considerable changes in water quality and regime. The major findings of this program indicated that a reduction in forest cover generally results in greater water yields (Swanson, 1973). However total clear-cutting is required to obtain significant increases (Swanson, 1973). Complementary snow management programs would also be an important factor. Water yields decline considerably as vegetation is established in the clear-cut area and therefore, on-going clearing is required (Swanson, 1980). However, observations by Leaf (1975) and Neill (1980) indicate that small scale reduction in the cover density obtained through such practices as sanitation cutting generally has little impact on yields.

The entire Alberta Watershed Research Program has been focused upon yield improvements without any consideration of the potential for increases in sedimentation, resulting from the erosion of exposed soils, or the possibility of considerable alteration of regime. The application of such a scheme is not compatible with outdoor recreation, and precludes many other land uses. Existing land allocations such as the National Parks form a considerable portion of the East Slopes and are effectively precluded from management.

Exclusion of these critical watershed areas from treatment would certainly limit the potential for yield increases. Extensive clear-cutting could also have considerable negative impacts on both on-site and downstream areas, in terms of the effect on regime and quality. Therefore, a watershed management program oriented toward yield improvement would be of little practical value.

In summary, the management emphasis of the E.R.F.C.B. upon yield improvement tended to subordinate the importance of water quality and regime, as watershed management objectives. The management conflicts inherent in emphasizing yield improvements, while simultaneously attempting to protect watershed values, regime and water quality, clearly indicates that watershed management objectives have never been adequately defined. These conflicts also serve to illustrate the need for a methodology through which resource management conflicts can be identified, evaluated, balanced and ultimately, resolved. In order to accomplish this task effectively, watershed management objectives must be defined in much greater detail. Simple recognition of the importance of the study area and East Slopes in general, as a water-producing area, is not sufficient.

3.3.2 Canada Land Inventory - Foothills Resource Allocation Study

Increasing pressure for resource development and increasing land use within the East Slopes region, has resulted in some use conflicts and environmental degradation. This situation, and the potential for more serious resource allocation problems in the future, resulted in public demands for the protection of environmental quality, maintenance of high quality outdoor recreational opportunities, and the protection of watershed conditions. In addition, the E.R.F.C.B. term was ending at this time, and it was recognized that something was needed to replace the E.R.F.C.B. in managing the East Slopes. In 1970, the Alberta Government responded to these identified needs by initiating the Foothills Resource Allocation Study. This study was a comprehensive planning process designed to identify optimum resource uses for land units, based on an evaluation of resource capability, present land use, economic value and resource demands (Alberta Government, 1977).

The Foothills Resource Allocation Study was completed in 1973 as part of the Canada Land Inventory (C.L.I.) program. This program, jointly sponsored by Environment Canada and Alberta Lands and Forests, was designed to develop a comprehensive planning program capable of determining the most beneficial allocation of resources in the East Slopes region, based on resource productivity and economic considerations (Foothills Resource Allocation Study, 1973). The stated objective of this program was to determine the best allocation of resources in a multiple use context and thereby ensure that each land unit is managed for that combination of resource uses which realizes the greatest net benefit to society (Foothills Resource Allocation Study, 1973).

Originally, this program was to include four phases; 1) physical capability, 2) current supply and demand, 3) projections, net revenues and capitalized values, and 4) regional land use plan. Phase 1 (physical capability) was intended to provide an assessment of the physical capability of the land to supply various resource uses. Phase II (current supply/demand) was designed to evaluate current demands being placed on the various resources of the foothills region. Phase III (projections) was intended to provide forecasts of the quantity of each resource demand to 1985 and to assess the amount of these projected demands which could be supplied in the foothills region. Phase IV (regional land use) included the preparation of a regional land use plan, incorporating the supply and demand relationships, as well as the capitalized values from phase II and III, and the physical capability data and effects of resource interaction from phase I. This plan was also to have included an assessment of constraints on present land use (Foothills Resource Allocation Study, 1973). However, only the phase I study was completed. The other three phases were aborted and decision-making based upon phase I alone, could not be complete. This was perhaps the major limitation to the Foothills Resource Allocation Study.

The data analysis completed under phase I of this study, was basically intended to provide the base information necessary to fulfil this objective. Although the stated objective was sound, the basic assumptions were not well defined and the methodology and assessment procedures were not adequately developed. This approach to multiple-use resource management has serious implications for both watershed management and outdoor recreation.

The phase I report completed for the Cline-Siffleur Drainage District, which includes the entire study area, provides a basic outline of the research design. Basically, the phase I report is intended to present the design of procedures used and an analysis of the results of the assessment completed therein. Secondly, the authors of this study attempted to determine the type of physical and socio-economic data required to prepare a comprehensive plan, as well as to assess the available planning base information. To accomplish this, several data sources were used to provide information on 16 resource uses: archaeology, agriculture, coal, forest capability, forest cover, livestock grazing, industrial development, minerals, metallic minerals, oil and gas, recreation, sport fish, ungulates, waterfowl, watershed and key ungulates (Foothills Resource Allocation Study, 1973). Six inventories had been completed under the C.L.I. program and ratings were established to indicate the capability of the land base to support each of these uses. These inventories were completed for agriculture, forestry, recreation, sport fishing, ungulates and waterfowl. The Foothills Resource Allocation Study researchers apparently recognized deficiencies in the C.L.I. data base. This information was supplemented with other existing resource base information such as forest cover inventories, a classification of grazing range for livestock, and the identification of ungulate key ranges (Foothills Resource Allocation Study, 1973). Watershed information, in a form useful for the study, was obtained from existing records compiled by Alberta Lands and Forests (Foothills Resource Allocation Study, 1973).

Although a considerable amount of information had been collected, there were several problems with the resource categories and methodology used in the Foothills Study. One major problem was that some resource categories (e.g. watershed) were not well-defined. Some categories, such as forestry and ungulate capability were self-explanatory, while other categories, such as watershed and recreation, were not defined in sufficient detail to have any meaning in a comprehensive resource assessment. For example, different forms of recreation have different resource requirements and different degrees of compatibility or conflict with other resource uses. The resource requirements for downhill skiing are considerably different from the resource requirements for auto-access camping, yet these differences were not considered. All recreational activities were grouped into one single recreation category (Foothills Resource Allocation Study, 1973). A more realistic approach would have been to separate out each recreational activity as a category, based on specific land or resource requirements.

A similar problem was evident in the watershed category. The term "watershed" could be defined as the "area drained by one river system." However, a "watershed" can be managed for different outputs, all of which are conflicting to some extent. These different outputs tend to be compatible with or conflicting with other resource uses to varying degrees. For example, ideal watershed conditions for yield improvement are considerably different from the ideal watershed conditions required to ensure maintenance of regime and water quality. On this basis, the watershed category should be divided into at least three subcategories; yield, regime and quality. The land capability for each subcategory could be assessed in terms of the potential to optimize yield, regime or quality within existing environmental conditions and within the context of desirable watershed management objectives for the study area, in relation to other proposed resource uses. For example, if an area is rated as having a high capability for supplying a given water yield, with an acceptable regime pattern and water quality level, and the maintenance of this condition is highly desirable, vegetation maintenance and erosion control would be important prerequisites. If watershed was defined as the preferred resource use on these terms, emphasizing secondary resource activities, such as forestry operations, grazing or the enhancement of ungulate range, would not be totally compatible objectives. On the other hand, if yield improvements were desired, extensive vegetation removal would be required and this could be compatible with forestry operations. However, this would not be compatible with many forms of outdoor recreation and could also alter regime and water quality to the point where sport fishing could be compromised.

In addition to the problems resulting from inadequate definitions, all resource uses are also assumed to be equal in value and are rated as such. If dollar values were assigned to all resource categories such as grazing, forestry, recreation and watershed, uses would not have equal value. By weighting resource outputs on an economic basis, the relative value of a given unit of one resource as opposed to another, can be more fully assessed and a preferred resource or preferred group of resources can be identified. Wilm and Dunford (1941) in studies in the Eastern Slopes of Colorado, rated the value of grazing at $2.00 per acre, forestry at $20.00 per acre, recreation at $200.00 per acre and watershed at $2000.00 per acre. On this basis, watershed would have the highest resource value (Laycock, 1973; Wilm and Dunford, 1941).

In the Foothills Study, the assumption that watershed is of equal value with all other resources (combined with a lack of adequate definition) compromises the importance of watershed, relative to other resource uses. The importance of watershed as a resource is also assumed to be highly compatible with all other resource uses. However, this is not always true.

In the Cline-Siffleur Drainage District (study area) as in most of the Foothills region, ungulate range is assigned the highest area weighted total, with half the District rated as having high capability for ungulates, with more than 100km^2 being rated as key winter range (Foothills Resource Allocation Study, 1973). This high rating for ungulates suggests that wildlife habitat is the primary function of the area. Watershed is also deemed to be totally compatible with this preferred use. However, if the watershed conditions were enhanced to improve regime and quality, emphasis on ungulate range, would not be a totally compatible objective. Ideal ungulate range conditions would consist of vegetated areas interspersed with large open grasslands, ideally having a 50/50 ratio. Ideal watershed conditions for maximum regime improvement, would consist of climax forest stands with minimal open grassland areas. Therefore, managing a land unit for these two resource outputs could result in potential conflicts, due to the different requirements of each use.

One major problem with the Foothills resource evaluation/weighting system is that resource integration is not given adequate consideration. For example, if two resource uses occur simultaneously within the same area, the resource value of one or both of these resources could be reduced, as a result of the limitations imposed upon one use, by the presence of another resource use or combination of uses. This deficiency relates back to the fact that all resource uses are rated equally in this assessment. The fact that the effects of multiple resource use on individual resource uses, has not been given adequate consideration, adds to this deficiency. Basically, the approach taken by the Foothills Resource Allocation Study researchers is highly single-use oriented, and emphasizes a definition of "prime use for specific land units." This approach tends to encourage mutually exclusive resource use. In reality, there is no real need to set aside areas exclusively for ungulate range, or other uses, especially to the extent noted in the Cline-Siffleur Drainage District assessment (Laycock, 1973). For example, several other uses can be integrated with ungulate range with only minimal impacts. In some cases, resource uses such as forestry can be compleentary to the enhancement of ungulate range (Swanson and Hillman, 1974). Therefore, a multiple-use approach in which the various potential uses can be weighted and potential use limitations can be assessed, is a highly desirable alternative to the approach taken in the Foothills Resource Allocation Study.

Although most of the Cline-Siffleur Drainage District is rated as having only moderate capability for watershed, the area weighted total is second only to ungulates (Foothills Resource Allocation Study, 1973). This partial recognition acknowledges the importance of the study area as a valuable source of water for the North Saskatchewan River system. However, inadequate definition of "watershed" and a lack of weighting, tend to limit the practical value of this assessment.

Ideally, a methodology could be developed in which the relative values of the various resource uses can be assessed (Laycock, 1973). In addition, resource uses should not be considered to be mutually exclusive even within relatively small areas (i.e. within a one hectare block). In order to achieve a much higher degree of resource integration, a methodology should be developed to evaluate the potential for resource use conflicts in a multiple-use situation. Using this type of approach, the impacts and limitations of the various combinations of uses can be fully assessed. Potential conflicts between uses and any necessary management trade-offs could also be identified. This type of approach to planning could be beneficial, in terms of providing an adequate data base, upon which sound land use and resource management decisions could be made.

This approach could be applied to resource management problems in the study area. Most of the land along the tributary streams of the North Saskatchewan, such as the Cline River, Coral Creek and McDonald Creek are rated as having a high capability for recreation. However, it must also be recognized that these areas are important to the maintenance and possibly the improvement of existing watershed conditions. If watershed capability were defined by objective (e.g. yield improvement, regime improvement, etc.) and recreation capability was defined by activity (e.g. backcountry hiking, auto-access camping, or downhill skiing), it would be possible to analyze the resource requirements of each use.

The degree of potential conflict or compatibility resulting from the integration of these two resource uses could be more fully understood and the necessary trade-offs could be evaluated, to determine the degree to which each resource use could be optimized. The fact that this degree of analysis cannot be accomplished using the methodology employed in the Foothills study, serves to illustrate the high degree of generalization employed in this assessment. As a result, the conclusions developed on the basis of this assessment specify that ungulate range and watershed are the preferred resource uses in most of the study area. The researchers further conclude that this area could also accommodate secondary resource uses such as dispersed recreation and sport fishing, which supposedly do not conflict with the preferred resource uses. However, these conclusions indicate that the potential for integrated multiple resource use has not been considered beyond a very basic level. Similarly, potential limitations to use and conflicts between uses has not been considered.

In summary, the Foothills Resource Allocation Study is not detailed enough to provide the basis for sound decision-making. This is largely due to the fact that the study did not proceed beyond the phase I level. The practical use of the study results is also severely limited due to the basic assumptions made. The equal weighting given to all resources, combined with a very weak assessment procedure, tends to over-generalize the land capability ratings and bias the preferred resource uses, to reflect a highly single-use orientation. This incomplete review of both resource supply and demand patterns, illustrates that more intensive use of these resources may be possible and may be more desirable for society as a whole. A more realistic approach could include assessing the capacity of the environment to support different resource uses. The effects of different demands upon the environment and also the capability of the land to support each potential resource use in relation to potential supply and demand patterns could also be evaluated using this approach. This level of detail might have been possible, had phase II and IV of the Foothills Study been completed. However, since this level of detail is not available, practical use of the Foothills study for management purposes, is very limited. Therefore, resource capability and demand assessments must become considerably more detailed, if any realistic resource management and land use plans are to be developed.

3.3.3 E.C.A. - East Slopes Public Hearings

In 1973, the Environment Conservation Authority conducted a series of public hearings designed to solicit public viewpoints and concerns regarding land use and resource development in the East Slopes. A total of 308 submissions and 14 commercial recreation proposals were presented during these hearings (E.C.A., 1973). The briefs presented during these hearings and the results of public opinion surveys, conducted in 1973, strongly emphasized watershed and outdoor recreation priorities (E.C.A., 1973). In addition, the need for an integrated resource management policy and comprehensive land use plans for the East Slopes region was also identified in the course of public hearings. (Alberta Government, 1977).

In preparation for the public hearings, a background document entitled "Resources of the Foothills" was prepared (Alberta Government, 1972). In this document there was recognition of the fact that demands for the resources of the East Slopes are ever increasing; and that social values place considerable emphasis on both resource consumption and conservation. In addition, it was also recognized that any resource use inevitably has consequences upon the ability to use other resources and that increased resource conflicts would arise, without proper land use planning (Alberta Government, 1972). It was noted that Albertan's must establish their land use priorities before any resource management or land use conflicts could be resolved and therefore resource management and land use problems must be approached on the basis of how much of a reduction in environmental quality is acceptable, in order to maintain economic gains (Alberta Government, 1972). It was also noted that guidelines must be established to limit the use of certain resources in certain areas and these guidelines would ensure that resources could be managed to ensure the greatest net benefit or whatever effects are deemed necessary or acceptable to society (Alberta Government, 1972). In this background material, there was also recognition that guidelines could be developed to limit, specify, or enlarge the range of choice, relative to resource and environmental management practices. In addition, it was noted that wherever specific use objectives are emphasized, appropriate trade-offs, in terms of environmental and economic quality, must be made (Alberta Government, 1972).

On the basis of these concepts, the Alberta Government recognized four factors relevant to the public hearings on land use and resource development in the East Slopes: First, the capacity of the East Slopes region to supply resources must be assessed. Secondly, present land uses within the East Slopes region and any existing land use commitments must be identified. Thirdly, demand for resources of the East Slopes region, for a wide variety of outputs, must be evaluated and fourthly, land use alternatives and opportunities must be assessed to reflect identified public priorities (Alberta Government, 1972). These were essentially the four components identified for inclusion in the 1973 Foothills Resource

Allocation Study. To facilitate public input, five alternatives or management strategies were advanced. These alternatives represented a complete range of land use goals, from the provision of total protection of the natural landscape and renewable resources, to the opposite end of the scale, where anyone interested in acquiring ownership of land in the East Slopes, for any purpose, would be permitted to do so. (Alberta Government, 1972). The three management strategies identified between these two extremes, provided for various combinations and degrees of land use control and resource management guidelines. Individuals submitting briefs were asked to assess their land use proposals in relation to these management strategies, using an integrated management approach.

However, despite the "alternatives" orientation of this background paper, public response tended to be highly single-use oriented, with the majority of submissions placing emphasis upon one particular use for an area. In most submissions, the possibilities of integrating other uses , and the degree of potential conflicts possible, or potential trade-off required, was not generally recognized. (E.C.A., 1973). This deficiency was particularly evident in the way watershed was assessed in most of the submissions. Despite recognition of the importance of watershed, very little consideration was given to the degree to which other resource uses may be complementary to, or in conflict with, watershed management objectives.

This deficiency is clearly evident in many of the submissions concerning proposed land allocations in the upper North Saskatchewan Basin. Kregosky (1973), proposed in his submission that two additional natural areas, (Wapateehk Canyons and Landslide Lake) and a large provincial park (Wapateehk Provincial Park), be established in the area surrounding the White Goat Wilderness Area, north of Highway 11. Kregosky argued that since there were no coal deposits, oil and gas leases, or merchantable timber stands, these areas could be established without resource conflicts (Kregosky, 1973). This land allocation would also provide a representation of the alpine ecosystem and Cordilleran physiographic zone, within the provincial park system, (Kregosky, 1973). The basis for this argument was that this land classification/allocation would afford maximum watershed protection to maintain the quality of water yields (E.C.A., 1973). Similar land allocation preferences were also put forward by Pharis (1973), representing the Alberta Wilderness Association. The Alberta Wilderness Association proposed that the Whiterabbit Creek watershed, covering some 715km², south of Abraham Lake, be given a "wilderness" designation, on the basis of its high scenic and watershed values (E.C.A., 1973). Pharis (1973) indicated that watershed and wildlife would be the two top priority uses for the Ram-Whiterabbit Wilderness, because both of these uses are entirely compatible with the "wilderness" classification. Pharis (1973) also proposed an expansion of the White Goat Wilderness Area to its original size of 780km², which would involve the addition of the 497km² deleted from this area in 1965, to allow for uses such as hunting, fishing and trail riding, which are prohibited activities in Wilderness Areas (E.C.A., 1973). This proposal would involve designation of the Cline River valley and its tributaries, including Coral Creek, Entry Creek, Shoe Leather Creek, Cataract Creek and McDonald Creek, as wilderness area. Again, the argument put forth by the Alberta Wilderness Association, emphasized the compatibility of extensive recreation, wildlife and watershed. Laycock, (1973) noted that this degree of compatibility may be true in some areas, if certain demand combinations are present, (e.g. if the Wilderness Area is closely protected from fire damage and the watershed management objective is one of regime improvement involving maximum vegetation growth). However, these conditions are not complementary to wildlife and in many instances are not complementary to wilderness management. For example, the practice of "letting fires go" in wilderness areas, although appropriate for maintaining ecosystems and improving ungulate range, would not be appropriate for situations where the watershed management emphasis is placed upon regime improvement. Laycock (1973) also noted that watershed management objectives might change through time. For example, in later years, the watershed management objective may be one of promoting yield increases and therefore, controlled forest cutting would be required and this would not, by definition, be an acceptable activity within a wilderness area (Laycock, 1973). Similarly, if regime improvements were more desirable, artificial storage to supplement low flows in the winter months, might be required and this would also not be possible in a wilderness area. This is especially relevant in reference to the proposed addition to the White Goat Wilderness, as four prospective damsites located on Cataract Creek, Coral Creek and on the Cline River were surveyed in this area in 1965 (E.R.F.C.B., 1969). On this basis, there are considerable conflicts possible, which were not given adequate consideration in the submissions by Kregosky and Pharis. Similarly, very little consideration was given to the integration of multiple-uses or to possible trade-offs required. For example, a submission by Calgary Power (1973) indicated that drawdowns at Bighorn for power peaking purposes, result in considerable fluctuations in reservoir levels on Abraham Lake. Since this results in considerable seasonal variations in water levels, leaving extensive areas of exposed mud flats along the shoreline, recreational use of the reservoir is not feasible or compatible with Calgary Power's operations (E.C.A., 1973c). This narrow management approach certainly limits opportunities for conjunctive recreational development, since Frechette (1970) and Benfield (1974) noted the recreational potential of the Abraham Lake shoreline as being low to moderate. Indeed, recreational developments not dependent upon actual use of the shoreline on a year round basis, would be possible. A commercial recreation proposal submitted by Van Dyck (1973) outlined plans for a major resort complex known as the Odyssey, to be constructed near the mouth of the Cline River, overlooking Abraham Lake (E.C.A., 1973b). On this basis, it would appear that exclusive land allocations can in fact create conflicts in resource management and therefore greater management flexibility is required to reflect changing needs and patterns and to ensure adequate integration of resource uses.

A submission by the Red Deer Regional Planning Commission identified these requirements and suggested that a more comprehensive approach to land use planning was required. Shaw (1973) representing the Red Deer Regional Planning Commission, noted that any sub-region within the Province is highly inter-related with other areas (Red Deer R.P.C., 1973). Therefore, any plans or decisions involving one region should be based on overall provincial policy and planning guidelines, which reflect provincial priorities (Red Deer R.P.C., 1973). The Commission analyzed the range of management strategies proposed by the Alberta Government and suggested adoption of management strategy C, which specified use of the East Slopes for renewable and non-renewable resource development, in an integrated manner, to reduce conflicts between resource uses and to minimize deterioration of environmental quality. The Commission acknowledged the value of the upper North Saskatchewan basin as a critical watershed, and recognized that any integrated land use activities must not result in any appreciable deterioration in watershed conditions (Red Deer R.P.C., 1973). In order to minimize this conflict potential, it was argued that watershed must be equated with other resource uses (Red Deer R.P.C., 1973). Even though watershed is not generally considered an active resource use, such as forestry, grazing or coal mining, it is nonetheless a valid use of the Basin and is one which may or may not be compatible with other resource uses (Red Deer R.P.C., 1973). It was further recognized by the Commission that resource use, with adequate guidelines for watershed, would be entirely dependent upon the watershed management objectives for the basin and that these objectives would largely determine the degree of compatibility of other secondary uses (Red Deer R.P.C., 1973). Subsequently, the East Slopes watershed should be protected from adverse development which could increase stream yields, alter the timing of runoff or result in increased stream sedimentation, in a manner not compatible with watershed management objectives and requirements within each basin. The Commission further recognized the importance of differential development impacts in that some portions of the watershed are more susceptible to deterioration than others (Red Deer R.P.C., 1973). Therefore, different degrees of compatibility or conflict could occur with different resource uses (Red Deer R.P.C., 1973). On this basis, the Commission identified the need for impact studies, to define the required protection zones and allowable development zones, on the basis of watershed capability. It was noted that these zones must be established before sub-regional plans are developed for any basin (Red Deer R.P.C., 1973). This approach is highly desirable, in order to assess watershed conditions, capabilities and opportunities for improvement with management.

The Red Deer Regional Planning Commission also considered the potential for direct use conflicts. For example, mountain valleys were recognized as logical places to construct reservoirs and also recognized as important travel corridors, recreational sites and winter range and migratory routes for wildlife (Red Deer R.P.C., 1973). The Commission also recognized the limitations placed upon future opportunities, due to exclusive use of lands or permanent land use allocations. Although water diversion schemes and additional storage are not presently warranted, additional water supplies for irrigation in southern Alberta or additional on-stream storage for regime improvements in the North Saskatchewan Basin, may be required in the future. Therefore, flexibility is required to ensure that these future requirements are not precluded by other resource uses or by stringent guidelines, which accompany some land allocations such as Wilderness Areas (Red Deer R.P.C., 1973).

However, despite the sound recommendations put forward by the Red Deer Regional Planning Commission and others, the single use approach, emphasized in the majority of the submissions made to the E.C.A., was largely incorporated into the recommendations made to the Alberta Government by the E.C.A., relative to East Slopes management. Therefore, rather than developing a policy which emphasized highly integrated and flexible resource management, a policy was developed which reflected the highly single-use orientation, evident in the majority of submissions made to the E.C.A.

3.3.4 East Slopes Policy - 1977

In July, 1977, the Alberta Government released a policy statement and general land use zoning plan for resource management within the East Slopes region, which also included the Athabasca and Smoky Basins. This policy statement was the end product of extensive planning studies, such as the Foothills Resource Allocation Study and the public hearings on East Slopes land use, conducted by the Environment Conservation Authority. Unfortunately, many of the deficiencies and conflicts inherent in the planning studies and in the submissions to the E.C.A., are incorporated in the East Slopes policy. Therefore, this policy could result in some major limitations to watershed management, in the long-term. These limitations are evident in both the policy statements and in the land use and resource management guidelines specified in the zoning framework.

According to statements contained in "A Policy for Resource Management of the Eastern Slopes," the highest development priority relating to land use and resource management, is to ensure a reliable supply of clean water for aquatic habitat and downstream users (Alberta Government, 1977). Although the importance of the East Slopes as a water producing area is well recognized, and "watershed" is identified as the "prime use" of the East Slopes, watershed management objectives, techniques and potential conflicts with other uses have not been given adequate consideration. Secondly, the generalized policy has been applied equally to the entire East Slopes region, without adequate consideration being given to the very considerable differences in regional water requirements, downstream demand patterns, and the considerable variations in both watershed conditions and opportunities for improvement with management, in each basin.

In the East Slopes policy statement, water was recognized as being a renewable resource, having three basic components, for which the watershed can be managed; yield, regime and quality (Alberta Government, 1977). The basic management techniques required to accomplish these objectives were also recognized (Alberta Government, 1977). For example, the policy statement includes reference to the fact that annual water yields can be increased through vegetation manipulation, regime may be significantly altered by snow pack manipulation and/or use of storage reservoirs, and that water quality is directly related to the condition of a watershed and its stream courses (Alberta Government, 1977). However, there is no recognition of the fact that these three management objectives are usually conflicting and therefore cannot be maximized within the same basin, at the same time (e.g. yield improvement versus regime improvement). This lack of adequate definition, combined with the assumption that these three objectives can apply equally in all East Slopes watersheds, is perhaps the major limitation of the East Slopes Policy, relative to watershed management.

A second major problem with this policy is that management emphasis is entirely upon the maintenance of normal streamflow (Alberta Government, 1977). This emphasis must be based on the assumption that normal streamflow is adequate to meet downstream demand; that normal streamflow will be adequate to meet downstream demands in perpetuity and that consequently, there are no opportunities or requirements for improvements upon one or more components of the existing streamflow in any basin, in the forseeable future. However, since water supply and demand relationships are highly variable through time, such a static approach to watershed management is not realistic. For example, it is highly probable that in the North Saskatchewan Basin, additional water may be required to augment low winter flows, as an option for increased pollution abatement downstream, if present pollution levels increase in the future (Stanley and Associates, 1974). In addition, there are certain to be land use changes in the upper North Saskatchewan Basin which will have some impact on streamflow components and subsequently cause some deviation from normal streamflow patterns. It is also highly probable that demand patterns will change considerably through time and that present, normal streamflow, will not be sufficient to meet these changing demands. Since the practical potential for yield increases is small, other means of increasing supply in the downstream and southern areas must be considered (Laycock, 1973). For example, interbasin transfer from the North Saskatchewan to southern basins may be one option (P.P.W.B., 1982). The focus of management might then be required to shift to regime improvement, including flood and erosion limitation, low flow augmentation, etc. combined with onstream and streamside uses in the East Slopes (Laycock, 1973; Calgary Power, 1973).

However, the major assumptions relative to watershed management, incorporated into the East Slopes policy, severely limit the practical definition of watershed management objectives which are basin specific and which reflect dynamic supply and demand patterns. This deficiency might limit the application of required watershed management techniques in some basins.

The problems noted with the policy statements are further complicated by the zoning guidelines. Basically, the Alberta Government has indicated that integrated land use planning is required to implement the resource management policies for the East Slopes (Alberta Government, 1977). The land use zoning plan contained in the policy report, applies at the regional level and is employed as a means of translating the Alberta Government resource policies into a planning or decision-making format (Alberta Government, 1977). This zoning plan identifies broad units of land for which policies and integrated management objectives are specified, including an indication of the types of uses that can be permitted (Alberta Government, 1977). These zones are designed to provide a basis for resolving potential land use conflicts. However, the primary purpose of zoning, as indicated in the East Slopes policy, is to allocate resources on a regional scale, with detailed management plans being identified as the mechanism for translating the policy and zoning guidelines into practical application (Alberta Government, 1977). Land use priorities are identified for each zone, based on an evaluation of five main factors; physical environment, existing resources, present land use, demand, and public interest (Alberta Government, 1977). However, there are several problems with this approach to zoning. For example, it is apparently assumed that the existing land use is the "best use" of the resource, in all cases. This may or may not necessarily be true at the present time and would certainly not hold true in perpetuity. For example, an area may be identified as prime recreational land at present, but this same land may also provide the only feasible site for construction of a water storage reservoir, required to meet future water demands downstream. Such a project may be in the best public interest in the future, with recreation being the best use at the present time. Therefore, the rigid zoning approach applied to the East Slopes, limits the possibility of responding to changing "public needs" as resource demands change through time.

The East Slopes policy also indicates that zoning allows for the appropriate utilization of the diverse resource base of the East Slopes, by directing integrated land management efforts toward maximizing the benefits derived from a region, while minimizing the resource conflicts and costs incurred (Alberta Government, 1977). However, this approach to land use/resource management tends to emphasize a single use, rather than management for multiple uses. This single-use approach is evident in the zoning framework and guidelines.

Three primary zones are identified; protection, resource management, and development (Alberta Government, 1977). Within these broad zones, eight detailed land use zones outline a range of permitted or restricted activities, which reflect the resource management priorities and objectives in each zone (Alberta Government, 1977). These eight zones include prime protection and critical wildlife under the "Protection" category, special use, general recreation, multiple use and agriculture under the "Resource Management" category and industrial and facility, under the "Development" category (Alberta Government, 1977).

Most of the upper North Saskatchewan basin is zoned 'prime protection,' with the exception of the Highway 11 corridor, which is zoned as 'general recreation,' and a small area adjacent to Abraham Lake, which is zoned 'facility'. The prime protection zone includes the high elevation forests and steep, rocky slopes in the study area. (Alberta Govenment, 1977). This zone is intended to provide protection for the picturesque mountain scenery and high watershed values (Alberta Government, 1977). The resource management guidelines for this zone specify that watershed protection will be a major concern, along with the preservation of rare or fragile environments (Alberta Government, 1977). Therefore, land use will be oriented towards dispersed backcountry recreation activities such as hiking, fishing, hunting and other non-mechanized forms of recreation (Alberta Government, 1977). The resource management guidelines imply that natural processes would normally be allowed to continue unimpeded. However, where considered essential, management programs may include fire control and sanitation cutting, where there is a proven hazard to merchantable timber outside of the prime protection zone (Alberta Government, 1977). The guidelines further state that wildlife habitat improvement will be considered and this will generally be accomplished through controlled burning or fertilization programs (Alberta Government, 1977). The watershed conditions that would be achieved through these resource management guidelines clearly are not "ideal" watershed conditions. For example, ideal watershed conditions for the maintenance of stream regime and water quality, would require mature, well established vegetation. The absence of fire protection programs, encouragement of prescribed burns and higher fire hazards resulting from increased backcountry use, could result in large forest fires in key watershed areas. The effects of fire damage could result in increased water yields, changes in stream regime patterns, such as accelerated runoff response, and a considerable deterioration in water quality, (Satterlund, 1972; Croft and Bailey, 1964; Kittredge, 1957). A very large-scale disturbance, such as one associated with a major fire, could result sedimentation problems. For example, significant increases in sedimentation of the Abraham Lake reservoir, could reduce storage capacity in the long-term. This could have downstream impacts, such as less water being available from storage to supplement low winter flow, which is essential to pollution abatement downstream. Therefore, this approach to watershed management, although beneficial relative to the objectives of yield improvements and enhancement of wildlife habitat, may conflict with watershed management objectives of regime and water quality maintenance and with the aesthetic requirements for backcountry recreation. Furthermore, reference to the downstream impacts indicates that two levels of conflict must be considered; conflicts within the basin and conflicts within the region (implications for downstream water demand).

A second major limitation in the resource management guidelines for the prime protection zone is that certain watershed management activities would not be permitted. Land use activities that would not be permitted in the prime protection zone include mineral exploration and development, commercial timber operations, domestic grazing, oil and natural gas explorations and developments and industrial developments (Alberta Government, 1977). Although the guidelines do not specifically refer to structural water resource projects, it is assumed that such developments might also be excluded. This could include the development of additional storage sites, bank stabilization, some forms of snow management and vegetation management. Therefore, by protecting the watershed, as outlined in the resource management guidelines, some opportunities for watershed enhancement may be limited in this zone. If water resource projects were deemed necessary, special exemptions could be imposed by the Government, to ensure the construction of any required project. However, this would compromise the intent of the East Slopes policy.

Guidelines have also been developed for major recreational facilities within the prime protection zone. Future commercial ski developments would be considered in this zone, since it contains the only suitable snow and terrain conditions in the East Slopes (Alberta Government, 1977). Pettapiece (1971) recognized potential downhill ski facility sites in the Sentinel Mountain and Elliot Peaks area of the upper North Saskatchewan basin, in rating land use capability based on soil studies. However, since these types of facilities can have considerable impacts upon watershed conditions, such as increasing soil erosion, land use practices would be controlled to prevent the modification of streamflow (Alberta Government, 1977). Similar guidelines could be established to control the impacts of major water resource projects within the prime potection zone. Therefore, the resource management guidelines for the prime protection zone could be reassessed to ensure better flexibility and to ensure that resource management objectives can be met in the long term, with minimal environmental impact.

This lack of management flexibility is also evident in the resource management guidelines developed for the general recreation zone. The valley corridor surrounding the North Saskatchewan River and Highway 11 is zoned as 'general recreation.' This zone is intended to provide for a wide range of extensive and intensive outdoor recreation opportunities in a natural setting (Alberta Government, 1977). Therefore, management would emphasize maintenance of the natural environment for recreational use. Although watershed protection is recognized as the major management emphasis throughout the East Slopes region and it is acknowledged that this concern cannot be satisfied by establishing a separate "watershed" zone, it would appear that recreation would take precedence over watershed in the general recreation zone (Alberta Government, 1977). Although most of the runoff is generated in the prime protection zone, all of this water passes through the general recreation zone before reaching the North Saskatchewan River. On this basis, watershed management and possibly watershed improvements, could be of considerable importance in this general recreation zone.

3.3.5 East Slopes Policy - 1984

In the summer of 1984, the Government of Alberta issued a revised policy for resource management in the East Slopes. In this revised policy, major emphasis is placed on tourism and development. As a result, much greater latitude has been provided for development in all zones. This could have major implications for watershed management. Although guidelines for the prime protection zone remain essentially unchanged, some considerable changes have been made to the guidelines for the general recreation zone. For example, activities such as logging, grazing, and coal, petroleum, and natural gas exploration and development are now "permitted uses" within the general recreation zone (Alberta Government, 1984). Although the potential for most of these uses is low in the general recreation zone within the study area, development of any of these uses, especially grazing, could result in a considerable deterioration in existing watershed conditions.

Another major limitation to watershed management and to good planning in general, is the fact that the established land use guidelines may not necessarily be followed. For example, it is stated in the revised policy that "since economic opportunities are not all known in advance, site-specific developments may be considered in any zone" (Alberta Government, 1984). However, this statement is balanced by the condition that; "the possibility of whether or not an activity or development should take place in a particular area must always be measured against the fundamental management intentions for the zone" (Alberta Government, 1984). On this basis, one could assume that political expediency could take precedence over good planning, for any proposed developments which may not be appropriate in relation to the zoning guidelines. The most significant implication for watershed management might be that developments having a significant impact on watershed conditions, such as mining or grazing, could be approved in critical watershed areas, or in other areas highly susceptable to impacts. Since actual watershed requirements are not defined to any extent in the policy statement, the importance of watershed could be subordinated in importance, relative to other uses, including site-specific developments.

Another major change in the revised policy is that regional watershed objectives have been defined for each of the major basins in the East Slopes. However, these objectives do not appear realistic, in relation to actual watershed management requirements. For example, the regional objective which applies to the upper North Saskatchewan Basin is; "To manage the North Saskatchewan and Athabasca River watersheds, to maintain natural flows and provide the option for future increases in water yields, through intensive management" (Alberta Government, 1984). However, since regime improvement and water quality maintenance are required in the upper North Saskatchewan Basin, a management objective emphasizing yield improvements does not seem appropriate. This is especially true since the watershed conditions required for yield improvement are the opposite of the conditions required for regime improvement and water quality maintenance. Therefore, the revised policy contains even more limitations to watershed management than the original policy.

The implications of the resource management and land use guidelines, incorporated in the East Slopes policy have potentially serious consequences for watershed management in the future. Ideally, watershed management objectives must be defined for each basin within the East Slopes on the basis of watershed conditions, upstream and downstream demand patterns, and opportunities for improvement through management. The degree to which various secondary land uses can be integrated into a basin, without unduly compromising watershed management objectives, may then be assessed. This approach would require basic information on how the various uses planned for an area affect streamflow components, such as yield, regime and quality, as well as information relating to conflicts between various uses. Various combinations and degrees of use would require assessment in order to identify potential impacts and use limitations. More appropriate zoning and land use guidelines might be developed on the basis of this information.

3.3.6 Rocky-Clearwater Management Overview

The Rocky-Clearwater Management Overview was initiated in 1978, to apply the East Slopes Policy and related land use and resource management guidelines, in a detailed management plan for the Rocky-Clearwater Forest. In this Management Overview, boundaries for the preparation of integrated management plans are defined, a generalized resource management strategy for the Rocky-Clearwater area is developed, and additional information requirements for the preparation of specific integrated management plans are identified (Alberta Energy and Natural Resources, 1980).

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The Rocky-Clearwater Management Overview study area includes the entire Rocky-Clearwater Forest and several large areas of Crown land immediately adjoining the Forest, for a total area of 18,000 km^2 (Alberta Energy and Natural Resources, 1980). The Rocky-Clearwater Management Overview provides an overall management strategy for the area which in turn would be used as a framework for identification of priorities for the preparation of specific management plans for units within the area. Nine forest management units are identified and placed in four categories, on the basis of priority requirements for specific integrated management plans (Alberta Energy and Natural Resources, 1980).

The identified priority for the Rocky-Clearwater area is to identify a permanent forest land base for sustained yield timber production, with secondary concerns identified relative to the development of management objectives for watershed, recreation, wildlife and grazing (Alberta Energy and Natural Resources, 1980). This strong orientation toward timber production may be valid in many portions of the Rocky-Clearwater forest, but has little relevance in the upper North Saskatchewan Basin or other major watershed areas. This strong orientation towards forestry is due in part to the approach taken to development of the Rocky-Clearwater Management Overview. Basically, a planning team approach was used with team membership consisting of representatives of the various Divisions of Alberta Energy and Natural Resources and one member from Alberta Recreation and Parks (Alberta Energy and Natural Resources, 1980). Other agencies such as Alberta Environment, Alberta Culture, Parks

Canada and the Battle River and Red Deer Regional Planning Commissions were also involved in the process in a consultative role (Alberta Energy and Natural Resources, 1980).

It is acknowledged in the management overview that watershed should remain the most important objective for integrated management planning, given the vital importance of the North Saskatchewan Basin, as a source of water for a very large number of downstream users (Alberta Energy and Natural Resources, 1980). However, despite this recognition, no consideration is given to how this objective might be accomplished in the context of integrated management planning, or in relation to timber production objectives.

The recreation potential and scenic quality of the Rocky-Clearwater area are recognized as being among the best in the East Slopes (Alberta Energy and Natural Resources, 1980). It is acknowledged that the Rocky-Clearwater area is already heavily used for dispersed recreation and that an ever-increasing demand for all types of outdoor recreation will require land use controls, applied through integrated management plans and zoning. However, no consideration is given to the constraints of these "recreational" controls on other resource uses.

These general deficiencies become more apparent when applied to specific units in the Rocky-Clearwater Forest. The Pembina-Brazeau unit, in which multiple use conflicts are deemed high and the Rocky Mountain House unit which has a similar level of resource management conflicts are the two areas most urgently requiring management plans (Alberta Energy and Natural Resources, 1980). The upper North Saskatchewan unit (R-6) is identified as a third priority for planning. Although the importance of conflicts within R-6, (recreational over-use)are recognized, it is acknowledged that these will be at least temporarily dealt with by the Bighorn-Kootenay Plains Management Plan, which is currently being developed (Alberta Energy and Natural Resources, 1980).

Specific development strategies and specific objectives are proposed for each unit. The development strategy identified for the R-6 unit is "recreation emphasis." The guidelines associated with this "recreation emphasis" are based upon the East Slopes policy statements for the prime protection zone. The policy states that land use in this zone will be strongly oriented towards dispersed backcountry activities, such as hiking, fishing, hunting, or other non-mechanized forms of recreation (Alberta Energy and Natural Resources, 1980). The management strategy proposed for this area, includes recommendations that any development must emphasize the enhancement of recreational opportunities for dispersed backcountry recreation. More intensive recreational development would be confined to the North Saskatchewan River Valley corridor (Alberta Energy and Natural Resources, 1980). In order to implement this strategy, two land allocation alternatives are proposed; a provincial park to cover the entire prime protection zone in unit R-6, or establishment of a provincial park to cover the North Saskatchewan River corridor, to alleviate the problems of recreational over-use and to provide a staging area for dispersed use of the prime protection zone (Alberta Energy and Natural Resources, 1980). To accommodate this second alternative, complementary legislation would be required to control impacts of recreational use, while accommodating uses (e.g. hunting) which are not permitted under the existing provincial park designation (Alberta Energy and Natural Resources, 1980).

This heavy emphasis upon recreation, tends to subordinate the importance of watershed in this unit. No real consideration is given to possible impacts of these land allocations and increased use on watershed conditions. In the watershed guidelines proposed, the requirement of identifying areas which are important from a watershed point of view is recognized (Alberta Energy and Natural Resources, 1980). However, the only criteria suggested for the identification of important watershed areas, is that these lie above the 1825 m contour (Alberta Energy and Natural Resources, 1980). Although these areas are important water sources, lower elevation areas, with potential watershed management problems, must also be identified. Since all runoff from the high elevation areas must pass through the lower areas, land use in these lower areas can modify the quantity, quality, or timing of runoff. Intensive recreational development in the valley corridor could certainly affect runoff. As a result, land use controls are also required in these areas, to ensure that watershed conditions are not compromised. However, this may not be possible, given the heavy emphasis on recreation and the proposed allocation of land for recreational purposes. Therefore, management for recreation objectives could conflict with management for watershed objectives.

The lack of recognition of watershed in relation to integrated land management has the potential for major limitations to management. For example, no consideration has been given to watershed requirements, in relation to operations at the Bighorn Dam. Therefore, there is no apparent recognition of the relationship between water demand, water supply management (Bighorn Dam) and watershed management. This may be partially due to the fact that two different agencies are involved. Alberta Energy and Natural Resources has responsibility for watershed management, while Alberta Environment has responsibility for water resources, including control of TransAlta's operations at Bighorn. The Rocky-Clearwater Management Overview has many deficiencies in terms of the consideration given to watershed in integrated resource management. The overview is apparently based on the assumption that watershed is entirely compatible with resource uses such as recreation. Therefore, the deficiencies in the East Slopes Policy have not been alleviated by integrated management plans, instead these plans have served to translate these deficiencies into practical application.

3.4 Summary

A considerable amount of biophysical information has been compiled for the upper North Saskatchewan Basin and the East Slopes in general. Resource inventories have mainly been completed to assess the potential for single uses such as forestry, grazing, wildlife, recreation, etc., but very few attempts have been made to integrate this information and identify how these capabilities are changed when other uses are present in the same area. For example, how does the resource capability for ungulates change when forest harvesting takes place? This type of information is urgently required if the implications of multiple use are to be fully understood. Until this information is available, integrated management for multiple use is not really possible. Alternatively, highly single purpose use of small areas has been encouraged by the East Slopes policy, with very little consideration given to impacts on other uses, alternative opportunities, or to balancing long-range management objectives.

A second major deficiency is that watershed is never adequately defined and is therefore assumed to be totally compatible with all other uses such as recreation, timber production and wildlife. What is really needed is an assessment to determine what watershed conditions are required to meet downstream and on-site demands. An identification of the potential change in these demand patterns and an identification of how other land uses can be assessed relative to watershed is also urgently required.

4. Watershed Management

4.1 General Background

The single-use approach to resource management, traditionally applied to the upper North Saskatchewan Basin and East Slopes Region in general, has resulted in poorly defined watershed management objectives and a lack of appropriate watershed management guidelines. A major deficiency in this single-use approach has been the assumption that management techniques oriented toward wilderness protection, backcountry recreation or wildlife range improvement would automatically provide for sound watershed management. Perhaps the main reason for this problem is that the term "watershed management" was never adequately defined. As a result, watershed management objectives and the guidelines and techniques necessary to realize these objectives, have not been considered in relation to these other uses (backcountry recreation/wilderness preservation). Consequently, if management continues to emphasize single resource uses, watershed conditions required to meet on-site and downstream water demands may deteriorate in the long term.

Land management in the upper North Saskatchewan Basin must conform with the provisions of the East Slopes Policy. In this policy, the East Slopes Region is classified into broad management zones and specific management objectives are defined for each zone. Although the majority of the study area is zoned as prime protection, with the valley corridor being zoned general recreation, several different management orientations are possible within the same general area (Alberta Government, 1977). Although these different management orientations (e.g. watershed protection, wildlife protection, backcountry recreation) are all deemed compatible within the zoning guidelines, the potential for conflicts between uses is considerable. The potential for conflict stems from the fact that little consideration has been given to possible limitations to use. For example, management for one prime use may compromise the management of secondary uses. This largely relates back to a lack of defined management objectives for the various uses. Therefore, the degree to which any given management strategy is in conflict with watershed management requirements, cannot be determined until watershed management objectives and objectives for other uses have been defined for the area.

In order to realize the goal of integrated resource management for multiple uses within the upper North Saskatchewan Basin, management objectives must initially be defined for each potential resource use. For the purposes of this thesis, watershed management, resource conservation and outdoor recreation will be the main uses considered for the study area. Some consideration will also be given to wildlife and other such uses. Watershed management objectives and strategies are discussed in this chapter. Management objectives and related management strategies for resource conservation and outdoor recreation are discussed in chapter 5.

Once management objectives have been defined for each of these uses and management strategies necessary to realize these objectives have been developed, the implications of these strategies can be identified, potential conflicts between these management strategies can be assessed and required trade-offs can be identified. These conflicts are discussed in chapter 6.

Alternatives for managing the upper North Saskatchewan Basin can be developed on the basis of land capability and use conflict information. Different degrees of emphasis will be placed on the importance of watershed management, in relation to management of the area for resource conservation and outdoor recreation purposes, in each of these "alternative futures". The development of alternatives will be based on the assumption that a land unit cannot be managed to optimize two different resource uses at the same time. Some degree of watershed management efficiency must therefore be sacrificed, in order to facilitate some degree of management for other purposes such as outdoor recreation, resource conservation and wildlife. Alternatively, some degree of management for outdoor recreation, resource conservation or wildlife could be traded-off in favour of more intensive watershed management. This approach could provide decision makers with the information necessary to assess the implications of each alternative and permits rational choices on this basis. The eventual selection of one alternative for implementation would reflect the relative importance placed upon on-site and downstream benefits of watershed management, in relation to on-site management for other uses. The alternative futures for the upper North Saskatchewan Basin are outlined in chapter 8.

Due to the traditional emphasis placed upon watershed and the fact that watershed is also identified as the "prime use" of the East Slopes, the definition of watershed management objectives is a logical starting point for this process (Alberta Government, 1977; E.R.F.C.B., 1969).Watershed management objectives can be defined and hypothetical management strategies developed. The implications of these watershed management strategies can be identified and can be assessed in relation to management strategies for outdoor recreation, wilderness and other uses. Management conflicts and trade-offs between watershed management and these uses may then be identified and evaluated. "Alternative futures" outlining different management strategies can be developed on the basis of this information.

4.2 Watershed Management Objectives

The definition of any long-term watershed management objectives for the upper North Saskatchewan Basin must be based on existing and potential downstream demand patterns as well as on-site water requirements. In order to define watershed management objectives, the components of streamflow (yield, regime and quality) must be evaluated in relation to these demands. Any deficiencies and opportunities for improvement upon these deficiencies must be identified. Maintenance or improvement of one or more components of existing streamflow would be identified as a watershed management objective. Once the objective has been defined (e.g. to improve upon water quality), specific land use guidelines can be developed to ensure that the objective can be realized. The extent of these guidelines and the degree of restriction applied to secondary land uses, will vary between basins. The degree of variance will be based on existing watershed conditions, the degree of improvement required, and the extent of potential impacts associated with secondary land uses, on the required watershed conditions. The degree to which any objective can be realized will depend upon physical limitations and on the presence or absence of competitive uses.

Within the upper North Saskatchewan Basin, the available water yield in relation to existing downstream demand patterns is believed to be adequate for the immediate future, assuming no major diversion or interbasin water transfers are undertaken (P.P.W.B., 1983; Foster and Sewell, 1982; Environment Canada, 1981). However, some potential exists for diversion and interbasin transfer of water from the North Saskatchewan to the Red Deer and possibly to the Bow River Basin, to augment flows in these basins for irrigation downstream (P.P.W.B., 1983; Laycock, 1981). If water is diverted from the North Saskatchewan Basin in the future, existing streamflow may not be adequate in relation to new downstream demands. This may necessitate further regime improvements through increased regulation at Bighorn, possibly supplemented by additional storage.

Although yield improvements are not required, a better distribution of seasonal flow is badly needed and maintenance of water quality and limitation of flooding, erosion and sedimentation is highly desirable (Laycock, 1965). Increasing urban development downstream results in increased water withdrawal for both domestic and industrial purposes. In winter months, increases in water withdrawals and increases in pollutants could possibly exceed the assimilative capacity of the North Saskatchewan River, due to reduced flow. Since the North Saskatchewan is a major water source for urban, domestic and industrial users downstream, the importance of maintaining this capacity is self-evident. On this basis, additional winter flow may be required in the future. Recently, TransAlta Utilities indicated that increased flow regulation is required at the Bighorn Dam for power-peaking purposes (Alberta Environment, 1982). This increased regulation could involve changes in the timing of releases, such as reductions in flow at night and on weekends and increased flow in periods of high demand for power (Alberta Environment, 1982). Changes in the timing of water releases could also provide a secondary benefit of increased pollution assimilation capacity downstream, to facilitate maintenance of water quality. Demand for increased power peaking capability and for additional augmentation of winter flow, could also require increased regulation of flow at the

Bighorn Dam in the future. Therefore, the primary regional watershed management objective in relation to downstream demands, should be to improve the seasonal distribution of flow. This could be accomplished through the development of a watershed management program, to complement the operation of the Bighorn Dam, relative to regime improvement. The intensity of watershed management required would depend on downstream demands relative to existing storage and on the potential for additional regime improvements. The success of any watershed management programs would be dependent upon physical limitations within the Basin.

Existing water resource developments in the upper North Saskatchewan Basin, such as the Abraham Lake reservoir, have specific watershed management requirements, which must be considered in the definition of watershed management objectives for on-site purposes. The maintenance of good watershed conditions is important for dam operation purposes. Certain land use activities within the basin could increase erosion substantially. Increased erosion results in increased stream sedimentation (Satterlund, 1972). Pettapiece (1971) noted that many of the soil types within the basin, especially those developed on alluvial fan sites within the North Saskatchewan River Valley, would be highly susceptible to erosion. This is especially true for areas of intensive use.

The potential for accelerated erosion would be of concern, since land use is presently concentrated in the valley area and there is considerable potential for increased recreational use in this area. This erosion potential, combined with the slope factors and high drainage density discussed in chapter 2, could result in stream sedimentation problems in the future. Pettapiece (1971) also noted that a problem might be encountered with sediment build-up at the point where the North Saskatchewan River enters Abraham Lake. It is also generally acknowledged that the North Saskatchewan River presently carries a substantial sediment load, due to its glacial origin (Pettapiece, 1971; McPherson, 1970). Therefore, reservoir sedimentation could become a serious problem in the long-term. Experience in mountainous areas in the United States indicates that reservoir capacity can be substantially reduced by stream sedimentation over a twenty-five year peiord (Hagan and Roberts, 1973; Croft and Bailey, 1964). Reduction in reservoir capacity could reduce the amount of water available for release during the winter low flow months. Reduction in winter water releases would in turn reduce both the power-peaking capability of the dam and also reduce the flow volumes necessary for pollution abatement downstream. Therefore, land management techniques applied in the upstream reaches of a basin may have a considerable, indirect impact on the realization of downstream objectives. Suspended sediments can also damage turbines, penstocks and other dam infrastructure, due to the scouring effect of this material as it passes through the dam (Hagan and Roberts, 1973). A high sediment load may also reduce the albedo of the water surface, resulting in an increase in water temperature and a deterioration in water quality (Chamberlin, 1982; Hagan and Roberts, 1973). On this basis, erosion control is also an important watershed management objective.

In order to realize watershed management objectives of regime improvement and erosion control, comprehensive watershed management guidelines and strategies are required to integrate watershed management programs with water resource operations. Realization of such a plan requires a recognition and understanding of the relationship between land use within the basin, the operational requirements of the Bighorn Dam, and the quantity, quality and timing of runoff available for both on-site and downstream demands.

Although regime improvement is an important objective, it must not be achieved at the expense of unacceptable reductions in stream yields or water quality. Management of the Basin for improved regime must not produce any significant reductions in yield. This would be especially important, should diversions and interbasin transfer take place in the future.

Management of water quality should stress the maintenance of natural conditions and this must be considered in any regime improvement programs. Certain land use activities or water uses may be appropriate to the objective of regime improvement. However, these activities or uses could negatively affect water quality, in the absence of careful planning. For example, on-stream storage for regime improvement could result in some direct and indirect reductions in water quality (Hagan and Roberts, 1973). The large volume of surface water exposed to direct sunlight results in considerable increases in evaporation losses and also increases water temperature in this surface water layer (Hagan and Roberts, 1973). Recreational use of the reservoir or adjacent shoreline, or the use of the reservoir for on-site sewage disposal, combined with these temperature changes, could have some effect on water quality (Croft and Bailey, 1964). Therefore, it is important to balance the objective of regime improvement with the maintenance of acceptable stream yields and water quality levels.

4.3 Land Capability Assessment for Watershed Management Purposes

Specific management guidelines must be established to control the impacts of various land use activities on watershed conditions. Since there are considerable variations in environmental patterns and watershed conditions within the basin, there are also subsequent differences in land capability for various uses. Therefore, a land capability assessment for watershed management purposes is required. Specific land units or watershed management zones may be identified on the basis of this assessment. These watershed management zones should reflect the different functions of various portions of the basin, relative to the generation of runoff. Management guidelines may then be developed and applied on the basis of potential damage to the watershed by other uses, within each management zone.

Watershed inventory and resource capability assessments are essential for comprehensive watershed management. However, despite the importance of such information, detailed watershed assessments have not been extensively used in Alberta. There are several methodologies for collecting baseline environmental information for watershed management purposes. Each approach has its own particular usefulness. Several U.S. researchers have emphasized the importance of land use classification for watershed management purposes (Lotspeich, 1980; Chamberlin, 1980; Cline, 1980). Essential to any such watershed assessment is a recognition of the holistic and dynamic nature of a watershed (Lotspeich, 1980). Generally, land is classified according to five main components: terrain, hydrology, climate, flora, and fauna (Environment Canada, 1980). These components are generally subdivided into more specific units such as precipitation, temperature, soils, aspect, etc. for more detailed description of the resource. The emphasis placed on any single component or group of components is largely dependent upon the specific orientation of the study and on the orientation of the researcher. For example, a land inventory completed by a soil scientist would emphasize soils. However, the main benefit of detailed watershed assessment is recognition of the multi-disciplinary nature of watershed management (Environment Canada, 1980).The inter-relationships among the various components of the watershed environment are also considered in detailed assessments. (Environment Canada, 1980; Chamberlin, 1980). This integrated, ecological approach to watershed land classification has numerous advantages over the use of several single discipline resource studies (Pfister, 1980). Because the interaction of the various environmental components is considered in an integrated approach, the impact of disturbances, land use, or management strategies in a particular zone, can be predicted more accurately, in relation to the other zones and in relation to the overall impact on the watershed (Environment Canada, 1980).

England (1970) developed a framework for utilizing land capability classes as a basis for determining hydrologic response variations within different areas of a watershed. This basic information could then be used to determine the impact of land use change on hydrologic response. The need for such a framework was based on the argument that total values for factors such as precipitation, evapotranspiration, and streamflow, although useful for determining the water balance of a large basin, give very little indication of patterns within a particular area of a watershed (England, 1970). Differences in environmental factors such as elevation, aspect, slope, soils, and vegetation, produce subsequent variations in areal precipitation, interception loss, evapotranspiration and runoff response (England, 1970). On this basis, a watershed is considered to be composed of zones having different environmental characteristics and varying in hydrologic response characteristics and importance, relative to total runoff characteristics (England, 1970; Ward, 1972). When a watershed is divided into discrete units, based on factors inherent in the land capability classification, such as elevation, slope, soil depth and structure, and vegetation patterns, the factors which account for variations in evapotranspiration and subsequent runoff, can be identified (Satterlund, 1972; England, 1970) Sub-dividing a complex watershed into zones, based on land capability, also provides the base information needed to assess the impacts of land use change on hydrologic response characteristics (England, 1970). On this basis, the effects of various land use alternatives or land management policies can be assessed. Opportunities for watershed improvement, or the potential for watershed damage, may then be identified and related back to defined watershed management objectives. Therefore, the hydrologic response of land increments within the watershed is closely related to land capability (England, 1970). Area specific land use guidelines may then be developed, based on this information (e.g. areas which require erosion control).

Pfister (1980) developed a watershed land classification based on vegetation-habitat type. This classification was apparently based on the assumption that vegetation patterns represent an integration of climate, topography and soils and therefore reflect the overall environment (Pfister, 1976). Vegetation characteristics, described in habitat type classification, such as measures of stand density, canopy coverage, and stand structure, relate to interception, evapotranspiration, snow accumulation and snowmelt (Pfister, 1980; Satterlund, 1972). Measures of undergrowth vegetation (species composition and cover) may also relate to runoff and erosion potential (Pfister, 1980).

Cline (1980) outlined the application of land-type mapping to watershed management. This classification was based on the fact that hydrologic response characteristics, particularly the timing of flow as a result of hydrologic events, is a direct function of slope and regolith characteristics (Cline, 1980). These physical characteristics provide the basis for Cline's land-type inventory and classification. Once the landforms have been defined within the land-type inventory, map units can be refined considerably by interpreting secondary characteristics (bedrock lithology, vegetation patterns and soil) for each map unit (Cline, 1980).

Satterlund (1980) noted that climatic influences are the principal factors in the hydrologic cycle and subsequently influence hydrologic response to land management practices. On this basis, Satterlund argued that sound watershed management decisions cannot be made without site specific climatic data. Therefore, it is necessary to classify watersheds on the basis of micro-climatic patterns (Satterlund, 1980). In order to accomplish this task, consideration must be given to precipitation-elevation relationships and to the interaction between these factors (Satterlund, 1980). Secondary variables such as slope characteristics, aspect, vegetation patterns and temperature, must also be taken into consideration (Satterlund, 1980).

Swanston (1980) developed a watershed classification system based on an assessment of slope stability and soil mass movement and erosion hazards, as related to forest harvest operations. Under this system, watersheds would be evaluated on the basis of potential soil mass movement hazards (Swanston, 1980). This would serve to identify problem areas, define slope failure mechanisms, and identify areas amenable to specific control or correction procedures (Swanston, 1980). This framework was based on a detailed assessment of environmental factors such as vegetative cover, hydrologic characteristics of the site, micro-climate, soil characteristics, bedrock lithology and structure, and terrain origin (Swanston, 1980).

The interaction between various environmental factors within a watershed, relative to the production of streamflow, is recognized in all five watershed classification frameworks. The close relationship of watershed conditions to streamflow characteristics (i.e. quantity, quality and timing of runoff) and the fact that different land use activities within a basin alter watershed processes and in turn influence streamflow characteristics, have also been recognized (Cline, 1980; Lotspeich, 1980; England, 1970). Highly detailed baseline environmental information is also identified as a prerequisite to watershed land classification in all five systems. This level of information would be required for the development of any comprehensive watershed management plans. Each of these five watershed land classification systems, or combinations of these systems has some potential for application to the upper

North Saskatchewan Basin. However, due to the highly generalized nature of this thesis, none is entirely suitable. Alternatively, a simplified watershed land classification has been developed, based on the watershed management zoning framework originally used by the Eastern Rockies Forest Conservation Board (E.R.F.C.B., 1969).

The land classification framework developed by the E.R.F.C.B. was based on the identification of land units having similar environmental characteristics. These characteristics included elevation, slope, surficial deposits, vegetation, precipitation and temperature (E.R.F.C.B., 1969). On this basis, three broad watershed management zones were identified, within the upper North Saskatchewan Basin; the headwaters zone, intermediate zone and valley zone (E.R.F.C.B., 1969). Although these zones provide a general framework for watershed assessment, the E.R.F.C.B. did not give adequate consideration to management of these zones, or to the implications of watershed management activities on secondary resource uses within the Basin. Watershed management objectives, zone specific management guidelines, and the impact of potential watershed management techniques were not considered.

In this thesis, a general zoning framework has been used to identify the watershed function and conditions within different portions of the Basin. Watershed management strategies and zone specific management guidelines have also been proposed on the basis of these watershed conditions and in relation to the watershed management objectives defined in this thesis. Although this approach is more detailed than that of the E.R.F.C.B., its limitations must also be recognized. A watershed management assessment of considerably greater detail would be required for the preparation of any comprehensive watershed management plans for the study area.

4.4 Methodology

In order to develop an appropriate watershed management strategy, a preliminary land use classification for watershed management purposes is required. Different watershed management zones can be identified which have different functions relative to the generation of runoff within the Basin. Watershed management zones will therefore have different management requirements and different capabilities for various types, combinations and intensities of land use. Therefore, the objective of the author of this thesis is to utilize the existing resource information obtained from the literature, supplemented by air photo and map analysis and field observations, to evaluate the study area in terms of watershed capability and potential use conflicts.

In this Section, the methodology used to evaluate the environmental condition, capability, and function of these zones is described. Zone specific management guidelines are also proposed. The techniques employed in the air-photo interpretation and the integration of this information with baseline data, obtained from various inventory and mapping projects, are also discussed.

4.4.1 Resource Map Analysis and Air Photo Interpretation

Four 1:50,000 scale resource maps depicting precipitation, topography, vegetation, slope and erosion potential were analyzed to obtain baseline information on the broad environmental patterns within the upper North Saskatchewan Basin. The environmental information obtained from these maps was then plotted on a 1:50,000 scale N.T.S. map series providing coverage of the study area, in order to determine general relationships between these environmental variables (Energy Mines and Resources Canada, 1977). Slope and erosion potential maps produced by the Alberta Research Council and forest cover maps produced by Alberta Energy and Natural Resources were analyzed and compared, in order to identify vegetation-slope-elevation relationships within the study area (A.R.C., 1981; Alberta Energy and Natural Resources, 1976). These broad patterns were then compared with precipitation-elevation relationships derived from maps originally developed by the Eastern Rockies Forest Conservation Board (E.R.F.C.B., 1969). The general watershed zones defined by the E.R.F.C.B. were then compared with the general environmental patterns plotted on the 1:50,000 N.T.S. maps (E.R.F.C.B., 1969). On this basis, general environmental patterns and inter-relationships of environmental variables within each watershed zone could be identified and evaluated. This also provided the basis for assessment of watershed conditions and the identification of the function of each zone, in relation to the production of streamflow within the basin.

A generalized air photo analysis was also completed for the upper North Saskatchewan Basin. Basic information on topography, slope, surficial deposits, vegetation, drainage and land use was obtained from the air photos, in order to supplement and verify the information obtained from the resource map analysis and literature review. Due to the size of the study area (approximately 1450 km^2) and the complexity of the terrain, a very generalized level of interpretation was employed.

52 air photos at a scale of 1:39,996, representing coverage of the study area, were initially interpreted (Department of Lands and Forests, 1957). Major land units were identified on the basis of similarities in watershed characteristics, such as topography, elevation, slope, surficial deposits, drainage and vegetation. Secondary characteristics, such as land-use patterns, roads, and trail development, were also interpreted within these major land units. An additional 103 air photos providing coverage of the same area, but at a scale of 1:15,840 were also interpreted, to obtain more detailed information on areas within the North Saskatchewan River Valley (Department of Lands and Forests, 1958). This information was also used to verify the information obtained from analysis of the 1:39,996 scale air photos. Information obtained through the interpretation of air photos and from the resource maps analysis was integrated to provide a preliminary indication of existing watershed conditions. On this basis, sub-zones were identified for the purpose of applying specific watershed management guidelines. Due to some deficiencies in this information, interpretation of some supplemental air photos was required.

The air photos used in the analysis were produced in 1957-58 and therefore these photos do not provide information on more recent land use changes. Developments such as the Bighorn Dam, Abraham Lake, Highway 11, recreational facilities, and recent forest fire damage in the southwestern portion of the study area, occurred after 1958. In order to alleviate this problem, partial air photo coverage from 1974 was utilized to obtain information on the Bighorn Dam and Abraham Lake area and the eastern portion of the upper North Saskatchewan River Valley. This involved the interpretation of 22 additional air photos at a scale of 1:24,000 (Alberta Lands and Forests, 1974).

A major fire in 1974 destroyed approximately 2,600 hecatres of sub-alpine forest in the Siffleur/Escarpement River area (Alberta Recreation and Parks, 1981a). 20 air photos at a scale of 1:31,680, also produced in 1974, were interpreted to obtain information on the landscape changes produced by this fire (Alberta Lands and Forests, 1974).

Although the 1974 air photos provided adequate detail for existing land use and vegetation patterns, the 1:24,000 scale photos were of low quality and were therefore not suitable for extensive interpretation. These quality problems were due to low cloud cover and related technical problems encountered during completion of the aerial photography (Alberta Energy and Natural Resources, 1975).

4.4.2 Field Surveys

Field surveys were carried out to provide an assessment of existing resource conditions within the study area and to ground-truth information obtained from the resource map analysis, air photo interpretation and background literature. An on-site assessment of existing watershed conditions was completed, to identify and evaluate disturbed sites and areas having a high potential for damage with existing use. The implications of increased recreational use were also assessed in terms of potential impacts on watershed conditions. On this basis, existing and potential management conflicts were identified for each watershed zone.

On-site assessments were completed in selected areas of the study area to evaluate the potential for both general and site-specific conflicts between watershed management and park development/management. Field surveys were completed within selected areas of the valley and intermediate zones. Land capability ratings assigned to different areas of the valley and intermediate zones by various researchers were also evaluated relative to watershed management and park management purposes, during the field studies (Benfield, 1974; Kregosky, 1973; Canada Land Inventory, 1972; Pettapiece, 1971; Frechette, 1970; E.R.F.C.B., 1969). Field surveys were not attempted within the headwaters zone due to difficult terrain and access problems. However, this is not considered a major drawback, since management conflicts are very minimal within this zone and air photo coverage is generally accurate.

The majority of field work was completed in the North Saskatchewan River Valley, between the east boundary of Banff National Park and the Bighorn Damsite. Four visits were made to the North Saskatchewan Valley in September of 1980, June of 1981, October of 1982 and May of 1983. Representative areas of the valley and intermediate zones within the North Saskatchewan valley were assessed in terms of susceptability to impact, watershed management requirements, and potential land use controls. Specific management conflicts in the Kootenay Plains area and environmental impacts associated with the fluctuating water levels on Abraham Lake were also examined. The October 1982 trip was limited to observations along the Abraham Lake shoreline and in the Bighorn Damsite area, with the shoreline area being assessed in some detail. A field assessment was also completed in the Siffleur River Valley, from the point of confluence with the North Saskatchewan River, upstream to the confluence of the Siffleur and Escarpment Rivers, in the Siffleur Wilderness Area. Field work was limited to an initial reconnaissance of the area to ground-truth some of the information obtained from the air photos and to assess changes in cover resulting from the 1974 fire. The recent fire damage in this area provides a good example of a disturbed site within the Basin.

The Cline River Valley was also explored in June of 1981, upstream from Abraham Lake, to the confluence of the Cline River and Cataract Creek. Field work in this area was limited to recording general observations only. The Cline sub-basin is of particular importance due to the potential for additional on-stream storage at Coral Creek, Cataract Creek and on the Cline River (E.R.F.C.B., 1969; Alberta Department of Agriculture, 1965). These potential damsites were visited during the field trip. There is also some potential for downhill ski developments on the slopes of Sentinel Mountain, above Entry Creek (Pettapiece, 1971).

However, this site was not visited. The implications of these potential developments in terms of watershed management and park management conflicts are discussed in chapter 6.

4.5 Watershed Management Zones

Where watershed management objectives have been defined for the basin and for the region, as noted in 4.2, it is possible to assess the impact of secondary land uses upon the watershed conditions required to meet these objectives. On this basis, secondary land uses may be prohibited, restricted or otherwise managed, to reduce conflicts with watershed management objectives. Therefore, general watershed management guidelines are necessary to ensure maintenance of the required watershed conditions.

A considerable degree of environmental diversity is possible within mountain watersheds such as the upper North Saskatchewan Basin. On the basis of this environmental diversity, secondary land uses and broad management guidelines may have considerably different impacts in different areas of the basin. Therefore, the basin must be zoned on the basis of watershed condition and potential for damage with other land uses. Three broad watershed zones have been identified for the upper North Saskatchewan Basin study area, as shown in Figure 6. The headwaters, intermediate and valley zones represent considerably different environments, having a distinct but interrelated function in the production of streamflow within the basin. These environmental differences between watershed zones are illustrated in Plate 11.

Secondary land uses or the application of watershed management techniques may have different effects within the different watershed zones. Therefore, due to variations in resource patterns and conditions within each zone, specific management guidelines must also be developed for each zone. However, all zone specific watershed management guidelines must be integrated with any guidelines developed for other watershed zones, and these must be related back to the watershed conditions to be maintained in the Basin as a whole.

FIGURE 6
WATERSHED MANAGEMENT ZONES

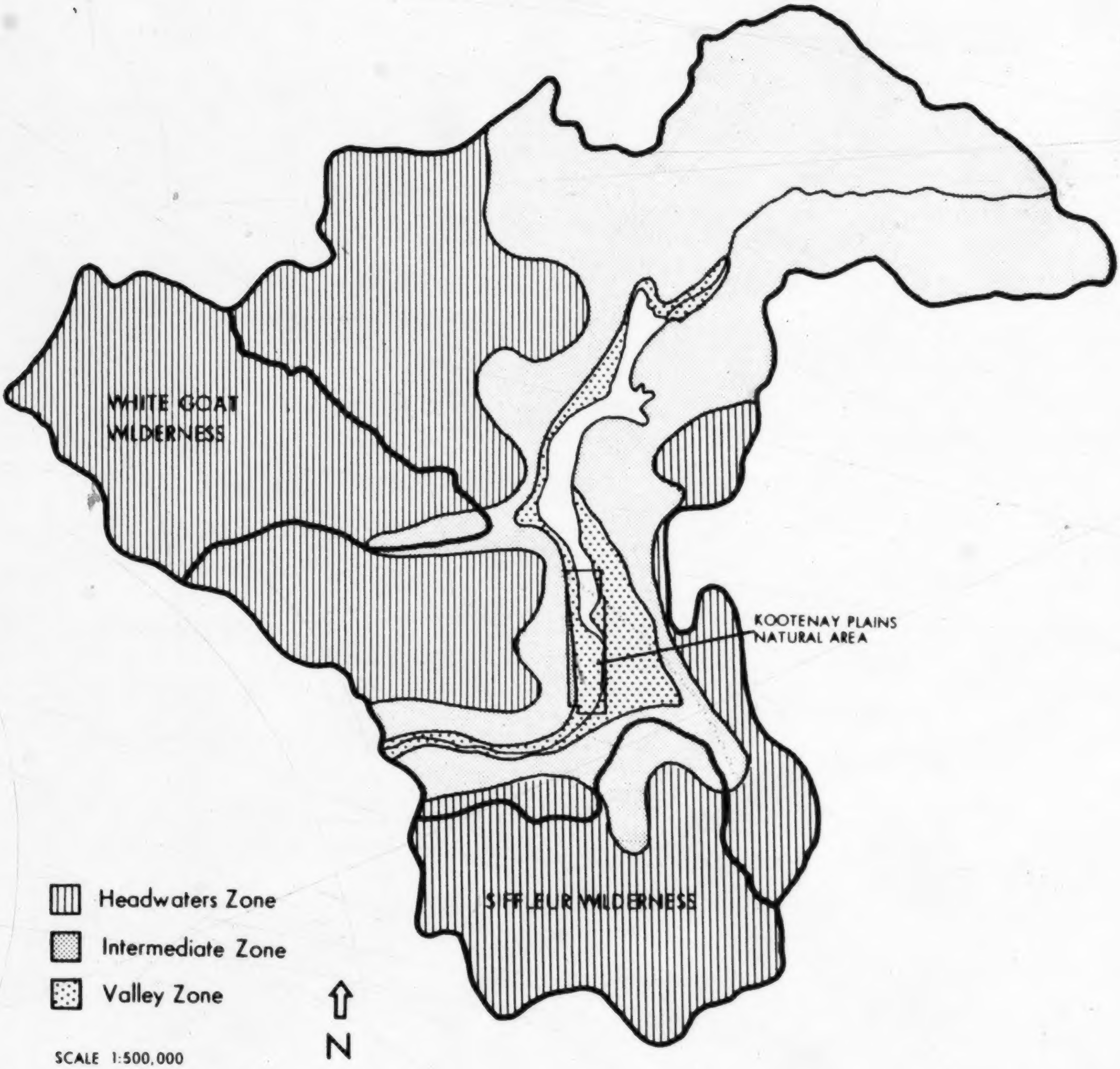
WHITE GOAT WILDERNESS
KOOTENAY PLAINS NATURAL AREA
SIFFLEUR WILDERNESS
▥ Headwaters Zone
▩ Intermediate Zone
⛆ Valley Zone
N
SCALE 1:500,000

Plate 11: Watershed Management Zones

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Headwaters Zone
Intermediate Zone
Valley Zone

The three watershed management zones are shown in this plate. The high elevation headwaters zone is shown at the top of the plate and consists of exposed bedrock. At the middle elevations, from treeline down to the point where the coniferous forest changes shade, is the intermediate zone. The valley zone is shown in the foreground.

The development of watershed management guidelines requires an understanding of watershed conditions and the inter-relationship between environmental factors within the basin and within each watershed zone. The effects of potential secondary land uses and watershed management guidelines, upon the required watershed conditions and subsequent impacts on the hydrologic cycle, must also be understood. On this basis, the general relationships between environmental variables within the Basin and within each zone, are described in this chapter. Management techniques and land use guidelines necessary to maximize the required watershed conditions, as described in 4.2, Watershed Management Objectives, are also discussed for each watershed zone.

4.6 General Environmental Relationships

Six environmental indicators are used to describe existing watershed conditions within each zone. These include; micro-climate, elevation, topography, slope, surficial deposits and vegetation. The interaction of these factors within each zone and within the Basin in general, determines the quantity, quality and timing of runoff.

Within the upper North Saskatchewan Basin and other watersheds, climate generally controls the quantity and seasonality of precipitation and general temperature regimes (Janz and Storr, 1973; Satterlund, 1972; E.R.F.C.B., 1969). Precipitation and temperature patterns are modified locally by elevational influences and slope factors such as aspect, which creates considerable micro-climatic variability (Cline, 1980; Pettapiece, 1971; E.R.F.C.B., 1969). This is largely due to the considerable elevational differences or sharp environmental gradient possible, over a relatively short distance, in any mountainous area.

The complex interaction between climate, elevation and topography has produced distinct differences in watershed characteristics. Topography reflects the origin and geomorphic history of the basin and largely determines slope, parent material, drainage and micro-climate patterns (Cline, 1980; Pfister, 1980; Pettapiece, 1971). Slope and surficial deposits (parent material), influenced by micro-climatic and elevational factors, determines the extent of soil development (Pettapiece, 1971). On this basis, soil development is highly variable within the study area, with several different soil types possible, within a relatively small area (Pettapiece, 1971; Laycock, 1965; 1957). Work by Pettapiece (1971) has resulted in detailed information on soil types and soil-vegetation-land capability relationships within the North Saskatchewan River Valley. However, only minimal information is available for other areas within the upper North Saskatchewan Basin.

The hydrologic response characteristics of a watershed, such as the quantity, quality and timing of runoff, is a direct function of slope characteristics and surficial deposits (soils) as modified by vegetation (Pfister, 1980; Swanston, 1980; Satterlund, 1972). Vegetative cover within the basin influences the amount of water intercepted, held in storage or lost through evapotranspiration, and ultimately determines the amount available for runoff (Cline, 1980; Satterlund, 1972; Ward, 1972; Hewlett and Nutter, 1969; Kittridge, 1957). Vegetation also influences the erosion potential of soils (Pettapiece, 1971; Laycock, 1965). Analysis of vegetation type and distribtion, cover density, and species composition, can provide an indication of potential losses to interception, evapotranspiration and soil moisture storage (Pfister, 1980; Environment Canada, 1977; Ward, 1972). Therefore, general vegetation patterns combined with erosion potential, as determined from the literature, forest cover maps, air photo analysis, and field surveys, was used as a primary indicator of watershed conditions, for the purposes of this thesis.

4.7 Assessment of Watershed Conditions

General watershed conditions were assessed within each watershed zone on the basis of vegetation condition and evidence of physical land disturbances, such as fire damage, slide areas, surface compaction, erosion damage and other indicators. Specific management guidelines required to meet the watershed management objectives (defined in 4.2), were developed for each zone. Potential management techniques for erosion control and regime improvement, which might be applied to enhance watershed conditions, are also briefly discussed for each watershed zone.

4.8 Headwaters Zone

4.8.1 Physical Description

The headwaters zone covers the high elevation, rocky, alpine and sub-alpine terrain within the upper North Saskatchewan Basin. This zone generally corresponds to the higher elevations of the Siffleur and White Goat Wilderness Areas and represents an area of approximately 730km^2 or roughly 50% of the study area. The lower boundary of the headwaters zone generally corresponds to the 2,130m contour. At this elevation, slopes are usually in excess of 60% (Pettapiece, 1971; E.R.F.C.B., 1969). Exposed bedrock slopes are the predominant land forms within this zone (see plate 12). Soil development is generally poor within this zone and is mainly confined to scree deposits evident on the medium and lower slopes as shown in plate 13 (Pettapiece, 1971).

Annual precipitation in the headwaters zone generally ranges between 95 and 125 cm water equivalent (E.R.F.C.B., 1969). Precipitation may be well in excess of 125 cm in some localized areas and more than 65% of total precipitation occurs as snowfall (Janz and Storr, 1977; E.R.F.C.B., 1969). This heavy winter snowfall combined with relatively cool temperatures at this elevation, results in extensive snow accumulations. These high elevation areas normally have snow fields that persist until late summer, although some permanent snow courses exist in some years, above 2,750m within the Cline and Siffleur watersheds (E.R.F.C.B., 1969).

4.8.2 Watershed Function

The most important function of the headwaters zone is to supply water for runoff (E.R.F.C.B., 1969). A combination of high precipitation and low evapotranspiration, produces a high water yield of good quality, with a well distributed flow. The absence of vegetation over

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Plate 12: The Headwaters Zone

The plate above shows a typical landscape characteristic of the headwaters zone. The rugged terrain with poor soil development (as shown below) is a major limitation to land use.

Plate 13: Typical Terrain - Lower Headwaters Zone

most of the zone results in extremely low interception and evapotranspiration losses, while poor soil development, combined with steep slopes and an impervious bedrock surface, results in minimal losses to storage or groundwater recharge. A hypothetical water balance calculated for this zone, would show a high precipitation input of 125 cms, a low evapotranspiration loss (assume 25 cms or less) and a large amount of water (120 cms) available for runoff. However, some of this runoff will be lost when it flows through the intermediate and valley zones. The estimated values are shown in the following hypothetical water balance, calculated for the headwaters zone using the Thornthwaite water balance equation (Thornthwaite, 1948; Laycock, 1957a).

$$P = (P.E. - D) + S$$

$$125\text{cm} = (25 - 20) + 120$$

P = Precipitation
P.E. = Potential Evapotranspiration
D = Deficit
S = Surplus

During the summer months, runoff response to precipitation input may occur very rapidly within this zone, due to the steep slopes and well-drained terrain. Runoff response to snow melt is considerably slower. Winter snowfall accumulates to a considerable depth within the headwaters zone, due to a combination of heavy snowfall, low temperatures, rolling terrain and moderate to high winds. Stunted vegetation at tree-line (2,200 m) may be an important source of snow accumulation (Martinelli, 1965). The erratic patches and bands of trees that constitute the upper edge of the sub-alpine forest and shrub vegetation in alpine meadows in many areas, are also effective traps for snow blowing off the ridges above (Martinelli, 1965; Anderson, 1960).

The snow pack melts gradually during the spring and early summer months. There is also a significant drainage of snowmelt into colluvial material (e.g. scree) where freezing takes place. The melting period may last well into the summer. These snowmelt patterns result in a moderate volume of runoff during the dry summer months of June, July and August

(E.R.F.C.B., 1969; Martinelli, 1965; Laycock, 1957).

4.8.3 Watershed Condition

The headwaters zone is in good condition for generating runoff and there is a low potential for watershed damage in most areas of this zone. The exposed bedrock slopes have a very limited capability to support secondary land uses and therefore have a very low damage potential. This fact, combined with poor access and rugged terrain, will ensure minimal impacts on watershed conditions within the headwaters zone. No disturbed sites are evident within this zone.

Scree slopes along the lower margins of the zone may have some potential for damage. However, the lack of secondary land uses should prevent this occurrence. The erosion potential of these scree slopes is generally low, since this material is coarse and not easily removed by intense rainfall or runoff. Therefore, watershed conditions within the headwaters zone are adequate in relation to the watershed management objectives and no potential management conflicts are anticipated.

4.8.4 Watershed Management Guidelines

Management of this zone should be oriented towards protection of the stunted vegetation and alpine meadow areas from fire and other natural enemies, as well as from the impact of uncontrolled recreational use. However, recreational use would have negligible impact on bare rock or colluvial sites. Since most of the headwaters zone lies above treeline, vegetation management would be appropriate for application only within the lower margins of the zone. Maintenance of these small, fragile, vegetated areas is important to prevent erosion of the thin, poorly consolidated soils on these sites. Land uses which could produce major surface disturbances, such as mining, must be controlled in this area. However, this should not present problems due to a lack of recoverable coal deposits within the zone. Higher elevation bare rock areas are highly resistent to impacts and do not require protection. Management of the headwaters zone should therefore be oriented toward maintenance these existing conditions.

Some possibilities may exist within the headwaters zone for snow pack management, for regime improvement purposes. Snow pack management may have some potential to improve regime for increased streamflow, in the late summer and early fall, based on the results of programs in Colorado (Martinelli, 1965). It is possible that snow trapping and storage, utilizing snow fencing or similar structures, would serve to reduce snow blowing off slopes or lost through sublimation. Application of materials to the snow pack, to enhance or retard snowmelt (depending upon water requirements), may also have some potential. Although no real net gains in total runoff would be expected, a better seasonal distribution of flow might result (Martinelli, 1965). On this basis, most watershed management techniques that could be applied within the headwaters zone would emphasize modification of snow cover or terrain rather than vegetation manipulation. Although it is not known how effective snow pack management would be in the upper North Saskatchewan Basin, land management guidelines should be flexible enough to permit the application of this or other techniques within this zone, if deemed appropriate to meeting watershed management objectives.

4.9 Intermediate Zone

4.9.1 Physical Description

The medium and lower mountain slopes, alluvial fans and fluvial valleys make up the intermediate zone. This zone generally includes the lower elevation areas within the Siffleur and White Goat Wilderness Areas, the Whiterabbit basin and upper Cline basin. The upper boundary of this zone corresponds to the lower margin of the headwaters zone at an approximate elevation of 2,130 m. The lower boundary of the intermediate zone corresponds roughly to the 1525 m contour.

The intermediate zone comprises approximately 30% of the study area. The slopes within this zone are characteristically steep, ranging between 30% and 70%, but have a generally lower gradient than slopes within the headwaters zone (Pettapiece, 1971; McPherson, 1970; E.R.F.C.B., 1969). The dominant surface material is a coarse textured, loose colluvium, with some talus and occasional rock outcrops (Pettapiece, 1971). Soils are generally better developed within this zone. However, soils vary considerably in depth and texture on a local basis (Pettapiece, 1971). As a general rule, the extent of soil development and soil depth increases toward the lower margin of the intermediate zone.

Mature coniferous forests cover most of this zone, as shown in plate 14. This subalpine forest is dominated by three main species; spruce (Picea engelmanni, Picea glauca), subalpine fir (Abies lasiocarpa) and lodgepole pine (Pinus contorta). Local variations in the occurrence of these species is evident in different areas of the intermediate zone. Only small areas of spruce-fir forests are evident. These occur in generally cooler, moister, north-facing sites or at higher elevations within this zone (Pettapiece, 1971). Engelmann spruce (Picea engelmanni) is the dominant species in the White Goat-Cline River area (Alberta Recreation and Parks, 1981b). Spruce and spruce-fir forests are generally representative of mature stands (Pettapiece, 1971; Rowe, 1959). The majority of the forest within the intermediate zone consists of pure stands of pine, with lesser occurrence of mixed spruce-pine forest (Pettapiece, 1971; Cormack, 1965). Lodgepole pine forest is indicative of recent fire damage. The predominant vegetation in the intermediate zone within the Siffleur Wilderness Area consists of immature lodgepole pine (Pinus contorta) with riparian willow (Salix spp.) and wetland vegetation established on alluvium in the Siffleur Valley (Alberta Recreation and Parks, 1981a). Sloping fen/bog systems are also found along some of the valley slopes in the Siffleur Valley (Alberta Recreation and Parks, 1981a).

Along the upper margins of the intermediate zone, the extremely arid sites on exposed slopes and ridges have very sparse tree growth, although the large amount of deadfall indicates a much denser stand in the past (Pettapiece, 1971). Scattered stands of aspen poplar (Populus tremuloides) are found on alluvial fan and talus slope sites, especially along the lower margins of the intermediate zone, in the North Saskatchewan River Valley (Alberta Recreation and

Plate 14: The Intermediate Zone

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Mature coniferous stands cover most of the intermediate zone such as in the background of this plate, which is the eastern side of Abraham Lake, approximately 6km upstream from the Bighorn Dam.

Parks, 1981a; Wallis and Wershler, 1981; Pettapiece, 1971). Balsam poplar (Populus balsamifera) is also found in the intermediate zone, in very moist sites on the lower margins of the alluvial fans and adjacent to some lower gradient stream channels (Pettapiece, 1971).

Understory species found commonly throughout the intermediate zone include Hedysarium (Hedysarium spp.), bearberry (Arctostaphylos uva-ursi), buffalo-berry (Sheperdia canadensis), junipers (Juniperus spp.) and heather (Cassiope spp.) (Alberta Recreation and Parks, 1981a; Wallis and Wershler, 1981). Twin flower (Linnaea borealis), bunchberry (Cornus canadensis) and feathermosses are also a common occurrence (Alberta Recreation and Parks, 1981a). Various grasses are also found on some of the lower exposed slopes within the intermediate zone. Therefore, the intermediate zone differs considerably from the headwaters zone in terms of vegetation patterns. The intermediate zone is characterized by generally mature, coniferous forest stands, with well established ground cover on both forested and open sites, as opposed to the large areas of exposed bedrock and marginal vegetation development within the headwaters zone.

Annual precipitation in the intermediate zone is substantially less than in the headwaters zone, with a lower percentage falling as snow. Precipitation ranges from 45 cm to 75 cm, with less than 50% of this total occurring as snowfall (E.R.F.C.B., 1969; McKay et al, 1965). Annual temperatures are also considerably milder in the intermediate zone, due to lower elevation (Pettapiece, 1971). However, extreme climatic variability is very evident over relatively short distances within the intermediate zone. These climatic variations are due mainly to the influence of elevation, modified by aspect (Pettapiece, 1971; McKay et al, 1965; Croft and Bailey, 1964). Secondary factors such as winds and rainshadow may be more important local factors (Pettapiece, 1971). The influence of aspect is very noticeable, in the contrasts in forest stand density and species composition between north and south facing slopes and locally between east and west facing slopes. (see plates 15, 16 and 17) The differences in aspect and vegetation density affect precipitation, insolation, and evapotranspiration, which in turn affects the water balance of the slopes (Croft and Bailey, 1964). Although the importance of these local variations in water balance within the intermediate zone is recognized, watershed conditions and management guidelines would be the same for both areas of the intermediate zone. Therefore, both areas are considered as a single zone.

4.9.2 Watershed Function

Modification of runoff is the primary function of the intermediate zone. The intermediate zone forms a hydrologic buffer between the headwaters zone and the North Saskatchewan River. All runoff generated within the headwaters zone must pass through the intermediate and valley zones. Therefore, regime and water quality components of streamflow are greatly modified by watershed conditions within these zones. The intermediate zone is of less importance than the headwaters zone, relative to water yields. On this basis, the water balance of the intermediate zone is also considerably different from that of the headwaters zone.

A major influence on the intermediate zone water balance is the fact that annual precipitation is much lower, with less than 50% of this total occurring as snowfall. The snow cover which accumulates, also melts much earlier in the year. The mature forest cover and well developed understory vegetation, utilizes much of the available moisture, resulting in heavy interception and evapotranspiration losses. The thicker soils blanketing the middle and lower slopes of the intermediate zone also absorb a considerable amount of moisture produced by rainfall and snowmelt. Therefore, losses to soil moisture storage are significant within this zone. On this basis, a water balance calculated for the intermediate zone using Thornthwaite water balance equation might include the following values (Thornthwaite, 1948). Precipitation within the intermediate zone might range between 45 cm and 75 cm (E.R.F.C.B., 1969; Janz and Storr, 1977). An average precipitation value of 60 cm is therefore appropriate for this calculation.

Evapotranspiration losses would also be high, due to the mature forest cover established over most of the intermediate zone. Losses to evapotranspiration are estimated at 45 cm on this basis. A deficit of 5 cm might also be expected. On the basis of these figures, approximately 20 cm of precipitation falling within the intermediate zone would be available as runoff. Calculation of this estimated water balance is based on the assumption that the intermediate zone is not influenced by processes within the headwaters zone. However, this is not necessarily a reflection of the actual situation, within the upper North Saskatchewan Basin. Therefore, water input into the intermediate zone from the headwaters zone, in the form of snow blown down from higher elevations, overland flow, or streamflow, has not been considered in this example. The intermediate zone water balance is shown below:

$$P = (P.E. - D) + S$$

$$60 = (45 - 5) + 20$$

P = Precipitation

P.E. = Potential Evapotranspiration

D = Deficit

S = Surplus

The water balance calculated for the intermediate zone differs considerably from that of the headwaters zone, in terms a lower precipitation input, greater evapotranspiration losses, and substantially lower surplus available for runoff. There may also be considerable variations in the water balance of the intermediate zone from year to year, based on variations in annual precipitation (i.e. wet years vs. dry years). In dry years, surpluses might often approach zero for the lower slope areas and deficits based on summer precipitation shortages may result in severe fire hazards and limited vegetation growth (Laycock, 1965). There may also be considerable local variations at different locations within the intermediate zone. Variations in cover (e.g. species composition, age, density) and variations in surficial deposits and soils (having different storage capacities) modify local conditions considerably. Low storage materials are also widespread within the intermediate zone and therefore, deficits of greater than 5 cm are possible.

The sub-alpine forest within the intermediate zone has two major functions. The forested slopes act as a hydrologic buffer, providing a modification of runoff. Secondly, the

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Plate 15: East-Facing Slope - Intermediate Zone

Plate 16: South-Facing Slope - Intermediate Zone

Plate 17: Intermediate Zone - Cline Sub-Basin

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There are considerable local terrain variations within the intermediate zone. This plate depicts some of the more rugged and rocky terrain in the lower Coral Creek area.

forest cover serves to stabilize the soil on the relatively steep slopes, minimizing erosion and subsequent stream sedimentation. This ensures maintenance of good water quality within the Basin.

The influence of forest cover reduces the amount of precipitation reaching the ground surface. Rainfall strikes the vegetation surface and is caught in the leaves or needles. A portion of this water flows down the trunk to the ground surface as stem flow (Ward, 1972; Satterlund, 1972). Some of the water is also evaporated directly from the vegetation surface (Ward, 1972). Stand density and species composition mainly determine the extent of interception and evapotranspiration losses (Satterlund, 1972; Douglas, 1967). Mature coniferous forests in the mid to late succession stages, such as the spruce-lodgepole pine forests within the intermediate zone, are heavy water consumers (Satterlund, 1972; Goodell, 1963). This loss has an effect on the amount and timing of the water that is ultimately available for runoff (Satterlund, 1972; Ward, 1972; Goodell, 1963; Kittredge, 1957).

Mature forest stands also have a considerable influence on snowmelt (Swanson, 1977; Martinelli, 1965; Kittredge, 1957). Although less than 50% of the annual precipitation within the intermediate zone occurs as snowfall, snowmelt provides the major source of runoff (E.R.F.C.B., 1969). Snow accumulates in open areas and beneath the forest cover. In spring, the tree cover shades the snow, resulting in a considerably slower melt rate (Satterlund, 1972). This results in a more gradual release of water from snowmelt and a less dramatic runoff response. Therefore, vegetation characteristics such as species type and composition, and stand density, combined with other environmental influences, have a considerable impact on runoff response (Satterlund, 1972). This ultimately influences streamflow regime patterns on the North Saskatchewan River.

The presence of mature forest cover is also important for the maintenance of good water quality. Well established vegetation adds stability to the poorly consolidated soils found on the steep slopes within the intermediate zone. Research has demonstrated that erosion from the soil surface, produced by overland flow downslope, is greatest in the absence of vegetation cover (Ward, 1972; Horton, 1965; Leopold, 1963). Therefore, soil erosion is a potentially serious problem in mountainous watersheds (Satterlund, 1972; Croft and Bailey, 1964). The maintenance of well-established vegetation within the intermediate zone is therefore essential, in order to reduce stream sedimentation, and thereby ensure favourable water quality and regime patterns.

The watershed characteristics of the intermediate zone, such as micro-climate, physiography, soils and vegetation, exert primary control over the timing and quality of runoff, generated both in the intermediate and headwaters zone. Therefore, management guidelines established for this zone, must be based upon the recognition of ideal watershed conditions, in relation to required regime and water quality patterns. The impact of secondary land use activities on these components of streamflow must also be recognized.

4.9.3 Watershed Conditions

Watershed conditions in the intermediate zone could be described as generally good at the present time. The existence of these watershed conditions is largely due to a lack of secondary land use in the last three decades and considerable emphasis placed upon fire protection within this zone. The well-established vegetation tends to stabilize the steep slopes and also provides a hydrologic buffer to runoff, thereby resulting in favourable regime patterns as well as maintenance of water quality. Erosion from the soil surface tends to be most effective in the absence of vegetation, due to the effects of overland flow upon an unconsolidated surface (Satterlund, 1972; Ward, 1972; Leopold, 1953; Horton, 1945). Therefore, maintenance of favourable regime and water quality within this zone, is largely dependent upon maintenance of vegetation.

Specific sites within the intermediate zone vary in their natural degree of stabilization and therefore, vary in terms of resistence to deterioration. Each potential land use activity, such as logging, construction of roads and trails, or recreational use, presents specific erosion problems and varying degrees of impact upon watershed conditions, in different areas of the intermediate zone. Since there are no merchantable timber stands or known significant mineral deposits within the study area, deterioration of watershed conditions related to these activities, is not a potential problem.

Existing, informal, backcountry recreational use within this zone, has resulted in several site specific erosion problems. However, most of this damage has been relatively minor to date. Erosion along informal or poorly constructed trails results in increased stream siltation. This problem mainly arises from poorly located trails, which become erosion channels (Pettapiece, 1971; E.R.F.C.B., 1969). Evidence of this problem was noted in the Siffleur Wilderness Area, and within the Cline, Coral Creek and Boulder Creek valleys. This situation is also believed to exist in portions of the White Goat Wilderness Area since most of the trails in this area are also informal.

As a general rule, erosion potential tends to increase with slope angle and sparseness of vegetation (Satterlund, 1972). The glacial outwash, talus, and colluvial deposits at the lower slope elevations within this zone, have a generally low potential for erosion with existing recreational use (E.R.F.C.B., 1969). The till and alluvial fan deposits, found on the upper, steeply sloped areas of the zone, have a moderate erosion potential (E.R.F.C.B., 1969). Stream beds within this zone generally consist of very large, coarse, rock materials and these are not easily eroded. On this basis, stream conditions are generally good, with a low potential for deterioration with existing use. The potential for watershed damage with existing use is therefore low to moderate within the zone (Alberta Research Council, 1976; Kregosky, 1973; E.R.F.C.B., 1969).

Erosion could become a very serious problem with increases in recreational use or with related facility development within this zone. Increased use could result in increased site deterioration and increased fire potential. Extensive vegetation removal or other surface disturbance could result in greatly accelerated erosion, creating serious stream sedimentation problems. For example, recent fire damage in the Siffleur-Escarpment River area would have produced some localized increases in stream siltation. However, these problems have likely subsided due to natural site regeneration as shown in plate 18. No other significant disturbed sites are evident within the intermediate zone.

Since the existing watershed conditions within the intermediate zone are the result of minimal land use pressure, it is logical to assume that increases in recreational use and development could have an impact upon these conditions. For example, roads and trails may produce major impacts (Chamberlin, 1980; Enberg, 1963). However, it is generally recognized that roads and trails are necessary requirements for wildland management (Sidle, 1980; Swanston, 1976; Satterlund, 1972). Soil erosion and subsequent stream sedimentation, associated with road and trail construction in mountainous areas, often exceeds that of all other land use activities combined (Chamberlin, 1980; Satterlund, 1972; Enberg, 1963). Although stream siltation is often the primary problem resulting from the construction of roads and trails, other characteristics of streamflow may also be affected (Satterlund, 1972). For example, road and trail surfaces are devoid of vegetation, often compacted and resistent to infiltration, and generally have steep gradients (Satterlund, 1972). This means that all precipitation falling on these surfaces becomes surface runoff, which enters the stream channels very quickly (Ward, 1972). This can become a major problem on steep slopes in mountainous regions, such as those characteristics of the intermediate zone (Satterlund, 1972; Arnold, 1963; Varnes, 1958). Therefore, any land use or development within the intermediate zone could result in some deterioration in the watershed conditions required for regime and water quality maintenance. The complex relationship between watershed properties and stream characteristics must be considered in any assessment of land use impacts on watershed conditions. Changes in these watershed conditions produced by land use change, may therefore have a considerable impact on the quantity, quality and timing of runoff (Lotspeich, 1980). Protection against erosion and maintenance or improvement upon watershed conditions must have priority in the intermediate zone. Enhancement of natural conditions to further improve upon regime patterns or water quality may also become necessary in the near future. Appropriate land use controls and flexibility in land management are necessary in managing this zone. The application of

Plate 18: Intermediate Zone - Siffleur (Upper Saskatchewan) Sub-Basin

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Fire damage is evident over much of the study area. This plate shows some of the terrain in the Siffeur sub-basin, near the Siffleur Falls.

appropriate management techniques, in order to safeguard watershed conditions or where required, to improve upon these conditions, is also essential.

4.9.4 Watershed Management Guidelines

Maintaining or improving upon natural watershed conditions is the major management problem within this zone. Therefore, watershed management guidelines must be developed to ensure a high degree of watershed protection. Vegetation maintenance and erosion control are very important within the intermediate zone. Maintenance or improvement upon watershed conditions within the intermediate zone could be accomplished through application of the following guidelines (Newhall and Smith, 1964; E.R.F.C.B., 1969; Satterlund, 1972):

1. Regulation of all mining, oil and gas exploration and commercial forestry operations in the intermediate zone, to ensure these activities do not have an unacceptable impact upon watershed conditions.
2. Provision of a high level of fire protection.
3. Management of natural forest enemies such as mountain pine beetle and spruce bud worm.
4. Regulation of recreational use and related developments within this zone, to ensure a minimal impact upon watershed conditions.
5. Application of watershed rehabilitation or improvement programs as required to modify watershed conditions.
6. Water resource developments consisting of structural and non-structural water resource and watershed management programs, oriented toward the improvement of regime or water quality.

Erosion control is very important within the intermedite zone, relative to the operation of the Bighorn Dam in the valley zone. Therefore, major land disturbances such as those associated with mining and forestry operations must be controlled within the intermediate zone. These restrictions should not result in any major conflicts, since there are no significant coal or mineral deposits, or stands of merchantable timber within this zone. Should this situation change in the future however, watershed protection should take precedence over resource extraction activities, where this is shown to be in the best interests of Albertans.

Fire protection must be provided to ensure the maintenance of adequate vegetation cover within this zone. However, controlled burning in overmature stands could be considered to maintain healthy vegetation and to enhance wildlife habitat, providing this does not produce unacceptable impacts on watershed conditions. Fire, especially large burns in steep watersheds which are well vegetated, can result in significant increases in overland flow, increased flooding, considerable erosion, and subsequent increases in stream sedimentation (Newhall and Smith, 1964; Kittredge, 1957). For example, research in mountain watersheds in the U.S. Pacific Northwest area indicates that flood flows in steep gradient streams contain significant sediment loads (i.e. 50% of the flow is water, 50% of the flow is suspended sediments) (Newhall and Smith, 1964). Erosion and subsequent sedimentation of reserviors, resulting from such flows, has often exceeded 1500 times the normal rate (Croft and Bailey, 1964; Newhall and Smith, 1964). On this basis, fire protection is required to minimize the potential for accelerated erosion and subsequent stream and reservoir sedimentation. This level of protection might be provided by maintenance of the existing fire detection/suppression program levels within the basin. Protection against insect infestations and tree diseases is also required within the intermediate zone. This would require an ongoing vegetation monitoring program to permit early detection. Control or eradication measures such as chemical treatments, selective thinning, or sanitation cutting, may also be required in response to such infestations. Vegetation manipulation, such as controlled cutting to simulate natural forest succession, may also be required in overmature stands, to ensure maintenance of healthy vegetation growth. Any such vegetation management programs would have to be completed with minimal impact on the ground surface, in order to minimize erosion.

Most of the land use pressure within this zone is created by informal backcountry recreational use (E.R.F.C.B., 1969). Since these activities have some potential for watershed damage, recreational use and related developments must be controlled. Existing backcountry roads, trails and campsites should be upgraded to reduce erosion hazards. Adequate drainage must be provided on roads and trails to carry both surface flow and channel flow across roads and trails with minimal soil erosion (Satterlund, 1972). Revegetation of road fills, cutlines and borrow pits is also important for preservation of water quality and soil conservation (Newhall and Smith, 1964). Similarly, a lack of road and trail maintenance, improper use, or over use of these routes, can cause significant erosion problems (Croft and Bailey, 1964). Informal, poorly constructed, or poorly located trails on steep slopes, can also create unnatural drainage channels and result in erosion of the trail surface and the formation of gullies (Newhall and Smith, 1964). Therefore, due to the potential impact of increased recreational use within the intermediate zone, guidelines are required to balance watershed management objectives with recreation objectives, to minimize unacceptable, negative impacts upon watershed conditions.

Land management must also be oriented toward watershed management purposes. Legislative and policy flexibility is required to permit the application of management techniques which emphasize manipulation of the environment for watershed enhancement. The capability to utilize structural alternatives to improve upon natural streamflow conditions must also be ensured. It may also become necessary to rehabilitate disturbed sites within the basin. The extent of measures which must be taken to prevent surface runoff and soil erosion, depend upon the degree of site deterioration (Satterlund, 1972). In many cases, natural vegetation succession should stabilize the site, before significant stream sedimentation occurs (Kittredge, 1957). However, in badly deteriorated areas, it may become necessary to expedite revegetation of disturbed sites, in order to minimize erosion. Cultural measures of site rehabilitation, such as fertilization and seeding may be required (Newhall and Smith, 1964). Seeding of grasses or grains over a burned area, to ensure slope stability and erosion control, might be applied to reduce stream and reservoir sedimentation and to prevent deterioration in water quality (Newhall and Smith, 1964).

Structural techniques may also have some potential for application within the intermediate zone, especially in response to land disturbances. Methods such as contour terracing, to reduce sheet erosion or gulleying and to increase infiltration, in order to reduce overland flows, might be applied in disturbed areas or on slopes with a high potential for failure (Croft and Bailey, 1964). Other structural techniques might include the use of artificial slope stabilization or the use of channel stabilization structures such as check dams (Croft and Bailey, 1964). These structures reduce stream gradients and flow velocities and result in reduced channel downcutting (Newhall and Smith, 1964). Use of such structures may also reduce erosion and improve regime (Newhall and Smith, 1964; Kittredge, 1957).

There is also some potential for construction of small storage dams in the Cline sub-basin (E.R.F.C.B., 1969; Alberta Department of Agriculture, 1965). Three damsites were surveyed on Coral Creek, Cataract Creek and on the Cline River in 1965 (Alberta Department of Agriculture, 1965). If additional winter flows were required to meet changing downstream demands, development of these sites might be required to supplement the existing storage capacity of the Abraham Lake reservoir. This additional storage could provide for additional regime improvements. However, development of these sites would require special guidelines. When dams are under construction, bypassing streamflow through a diversion pipe or tunnel could be required, to minimize sedimentation of the Abraham Lake reservoir downstream (Newhall and Smith, 1964).

Site reclamation measures must also be applied following construction. Rehabilitation of disturbed areas, such as borrow pits, cleared lands above the reservoir, and construction campsites, is essential for erosion control and serves to reduce reservoir sedimentation on-site and downstream (Croft and Bailey, 1964; Newhall and Smith, 1964). Land use activities must also be strictly controlled on the slopes above any new reservoirs and specific land use guidelines would have to be developed for these areas, to ensure that watershed management objectives are realized.

Snow pack management may also have some limited potential for application within the intermediate zone. However, any such program would have to be developed as part of an overall snow pack management program for the basin. Within a forested area such as the intermediate zone, snowmelt rates may be affected by shading the snow pack surface (Martinelli, 1965; Anderson, 1960). Although snow accumulation and melt are affected by terrain variables, the greatest single effect is produced by the vegetative canopy over the snow pack (Martinelli, 1965; Newhall and Smith, 1964; Anderson, 1956). Vegetation removal in strips may serve to increase snow accumulation within these clearings and thereby improve both regime and yield (Swanson and Hillman, 1977; Anderson, 1960). Although the degree of improvement possible within the upper North Saskatchewan Basin through snow pack management is unknown, this option should remain open. Any potential vegetation manipulation programs, designed to accomodate snow pack management, would have to be based upon an evaluation of snowfall, vegetative cover, aspect, slope gradient, wind patterns and other environmental factors, as well as consideration of the benefits versus costs of such a program (Berndt, 1965).

The application of these management guidelines and techniques in the intermediate zone, may be of considerable importance in terms of meeting watershed management objectives in the long-term. Application of specific techniques and the development of additional on-stream storage, would largely depend on future events within the basin and on changes in downstream demand patterns. Additional storage may be required in the future for regime improvement for both on-site and downstream purposes. Erosion control, soil stabilization and fire protection are very important, to maintain or improve upon water quality and regime, and to reduce local flooding and reservoir sedimentation problems (Newhall and Smith, 1964; Croft and Bailey, 1964).

4.10 Valley Zone

4.10.1 Physical Description

The valley zone generally corresponds to the North Saskatchewan River Valley, between the east boundary of Banff National Park and the Bighorn Dam and includes adjacent areas below 1525 m in elevation. The valley zone also includes the Cline River Valley, between the confluence of Boulder Creek and the Cline River, 8kms upstream, and the point where the Cline River enters Abraham Lake. This zone also extends approximately 1 km upstream into the Whiterabbit Valley and 1.5kms upstream into the Siffleur Valley. The Bighorn Dam, Abraham Lake and Kootenay Plains Natural Area are the dominant features in this zone. The valley zone represents less than 20% of the study area or approximately 250 km^2.

Two distinct environments or sub-zones can be identified within the North Saskatchewan River Valley. The east-west portion of the North Saskatchewan River Valley extends from the Banff National Park boundary, east to Whirlpool Point, near the confluence of the Siffleur and North Saskatchewan Rivers. This sub-zone consists of alluvial fans with slope angles between 5% and 9% , grading down into the North Saskatchewan River Valley (Pettapiece, 1971). River terraces are also relatively common features within this portion of the valley (McPherson, 1970).

Vegetation within this portion of the valley zone consists primarily of lodgepole pine (Pinus contorta), with buffalo berry (Sheperdia canadensis) being the dominant understory species (Pettapiece, 1971). This area is generally well forested, with stand density becoming somewhat thinner near the North Saskatchewan River, where some grassland areas are also found (see plate 19).

Downstream from Whirlpool Point, the physiographic patterns are somewhat different (see plate 20). Within this sub-zone, alluvial fans are the most dominant terrain feature (McPherson, 1970). These alluvial fans also vary in slope between 5% and 9%, with a greater number of slopes having lower gradients (5-6%) (Pettapiece, 1971). At several points, two or more fans have coalesced to form a continuum several kms across (Pettapiece, 1971). A second type of alluvial fan is also found within this sub-zone. These fans have been formed by the larger confluent streams, most notably the Siffleur, Whiterabbit and Cline, and generally have less than 5% slopes (McPherson and Hirst, 1972). Some remnant terraces are also evident in portions of the valley (McPherson, 1970).

Plate 19: Valley Zone - Upstream From Whirlpool Point

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Typical vegetation pattern in the North Saskatchewan Valley, upstream from Whirlpool Point. This portion of the valley zone is generally well-forested, with stand density becoming somewhat thinner near the North Saskatchewan River. This portion of the valley runs east to west.

Plate 20: Valley Zone - Downstream From Whirlpool Point

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North Saskatchewan River flood plain, looking south from the east side of the river, near the footbridge. This portion of the valley zone runs north-south. The Kootenay Plains Natural Area is in the background. This 'prairie' environment provides a sharp contrast to the east-west portion of the valley zone, shown in plate 19.

A silty aeolian mantle has been deposited over much of this lower valley area and is highly variable in depth, to a maximum of approximately 20cms (Pettapiece, 1971). Therefore, soils within this portion of the valley zone are poorly consolidated due to the high silt content. There is considerable plant diversity within this portion of the valley zone. "Prairie" vegetation is present over a significant portion of the valley floor and over the lower fans (Wallis and Wershler, 1981; Pettapiece, 1971). The largest fans are the Whiterabbit Creek fan and the fan opposite the Siffleur River confluence, which have coalesced to form the Kootenay Plains (Pettapiece, 1971; McPherson, 1970). Mixed stands of aspen (Populus tremuloides) and lodgepole pine (Pinus contorta) occur sporadically within this portion of the North Saskatchewan River Valley (Pettapiece, 1971). Mature stands of Douglas fir (Pseudotsuga menziesii) are also common in the Kootenay Plains area (Pettapiece, 1971). Spruce (Picea glauca, Picea engelmanni) also occurs sporadically in the Kootenay Plains area, mainly in areas of sub-surface runoff and adjacent to stream channels, where moisture conditions are most favourable (Pettapiece, 1971). Understory vegetation consists of numerous varieties of grasses and numerous plant species(see plate 21). Buffalo-berry (Sheperdia canadensis) is most common under forest cover, while rose (Rosacea spp.) cinquefoil (Potentilla fruticosa), juniper (Juniperus horizontalis) and silver berry (Elaeagnus commutata) occur in the open areas (Wallis and Wershler, 1981). Various species of sage (Artemesia spp.) including worm wood (Artemesia dracunculus) and wild flax (Lenum lewisii) are also common (Wallis and Wershler, 1981; Kondla, 1979). The grassed areas of the Kootenay Plans also contain some bear berry (Arctostaphylos uva-ursi) and numerous leguminous species, in addition to the shrubs mentioned above (Wallis and Wershler, 1981). Numerous other species of vascular plants are also found within the Kootenay Plains Area, many of which are rare species (Wallis and Wershler, 1981; Kondla, 1979).

Vegetation patterns within the valley zone are considerably different from those within the intermediate zone. The valley zone consists mostly of open areas with low density stands of coniferous and deciduous trees occurring throughout the zone. This is a sharp contrast to the mature, coniferous forests of the intermediate zone. The vegetation patterns within the valley zone are largely the result of a combination of physiographic and micro-climatic influences. The east-west valley sub-zone, above Whirlpool Point, has slightly less precipitation than lower elevations within the intermediate zone. The Kootenay Plains sub-zone, on the other hand, has a dry, sub-humid to semi-arid climate, as demonstrated by the vegetation patterns. Since this portion of the valley lies at a lower elevation, within an area subject to "rainshadow effects" and frequent chinook winds, winters are more moderate and summers are considerably drier than in the intermediate zone (E.R.F.C.B., 1969). Precipitation is minimal, with annual precipitation averaging 35 cm (E.R.F.C.B., 1969). In dry years, precipitation may be substantially less. For example, in 1966-67 a storage gauge located in the Kootenay Plains Natural Area recorded only 14.2 cms of precipitation over a 12 month period (Pettapiece, 1971).

Snowfall within the valley zone is also very minimal, with only 36% of total precipitation occurring as snow (E.R.F.C.B., 1969). On this basis, annual snowfall is approximately 12.5 cms water equivalent. Snow is seldom deep during the winter, however some drifting does occur (E.R.F.C.B., 1969). The snow cover also disappears frequently during the winter months, due to the influence of chinook winds (E.R.F.C.B., 1969). Therefore, much of this accumulated snow cover is lost through sublimation. Any remaining snow melts very rapidly in the early spring, with some of the available moisture evaporated from the soil surface or lost to soil moisture recharge. The contribution of snowmelt to streamflow is therefore negligible within the valley zone. On this basis, snowmelt is of considerably less importance in the valley zone, than in either the intermediate or headwaters zones.

4.10.2 Watershed Function

All runoff generated in the headwaters and intermediate zones passes through the valley zone as streamflow. Therefore, watershed conditions within this zone have a major impact on water quality and a somewhat lesser impact on regime. The valley zone is not a significant source of runoff. The combination of low precipitation and moderate evapotranspiration losses results in a water deficit, with an insignificant and undependable surplus being available for runoff. The presence of "prairie-type" vegetation, well adapted to xeric site conditions, is indicative of a low precipitation input and near-drought conditions (Wallis and Wershler, 1981). The grassland is due partly to limited soil moisture storage capacities in many fans and terraces (e.g. in silts overlaying gravels). Soil moisture in many of these sites is not sufficient to sustain tree growth.

The dominance of shrub and grassland vegetation within the valley zone, results in lower interception and evapotranspiration losses. The lower interception capability of grasses and shrubs results in nearly all precipitation falling in the zone, reaching the ground surface. Grasses and shrub vegetation also produce lower evapotranspiration values than forested areas (Satterlund, 1972; Hewlett and Nutter, 1969).

A water balance calculated for the valley zone, using the Thornthwaite water balance equation, might include the following values (Thornthwaite, 1948). Precipitation input would be approximately 40 cms based on average annual precipitation recorded in the Kootenay Plains area (E.R.F.C.B., 1969). Potential evapotranspiration would be approximately 45 cms, based on the vegetation cover type present in this zone (Laycock, 1957a). A deficit of 10 cms would be expected, with a minimal surplus of 5 cms available as runoff. Surpluses would be the product of better than average months/years. In some of these wet periods, erosion could be a problem. Much of the erosion would be caused by streams rising in bare rock areas, at higher elevations, where larger surpluses are common. These estimated values are shown in the following water balance equation.

$$P = (P.E. - D) + S$$

$$40 = (45 - 10) + 5$$

P = Precipitation
P.E. = Potential Evapotranspiration
D = Deficit
S = Surplus

Although contribution to water yield is minimal, the valley zone is of considerable importance to water quality and to a lesser extent, regime. The well-established grasses, shrubs and sporadic tree cover stabilizes fragile and easily eroded soils (See plate 22). Even though slope gradients are considerably lower in the valley zone than in the intermediate zone, the erosion potential is considerable, due to the high silt content in the soil (See plate 23) (Pettapiece, 1971). The presence of this vegetation also provides some buffer to runoff response, by minimizing overland flow within the zone. Since the maintenance of vegetation is important within the valley zone, land disturbances must be minimized, to limit soil erosion. Alteration of watershed conditions within this zone could result in increased stream sedimentation and some deterioration of water quality, within the upper North Saskatchewan Basin and in downstream areas.

4.10.3 Watershed Conditions

Watershed conditions in the valley zone could be rated as moderate to good at the present time (E.R.F.C.B., 1969). However, there is some potential for watershed damage with existing use. The low gradient alluvial fans, stabilized by well-established ground cover, have deteriorated somewhat with existing use. Recreational use within this zone has been relatively heavy to date, resulting in some surface disturbances (E.R.F.C.B., 1969). Gully erosion is often a major problem on horse trails, cutlines and fire roads. In addition, overgrazing by horses, elk, and deer has been severe in some years and localized areas of the grassland are in poor condition, due to trampling and concentrated grazing.

Land use pressure in the valley zone is much greater than in either the intermediate or headwaters zone. Recreational use is expected to increase substantially in the near future (Kregosky, 1973; Pettapiece, 1971). The David Thompson Highway, which parallels the North Saskatchewan River through the valley zone, is becoming a major tourist route to Banff. This factor, combined with ease of access and the high environmental quality and scenic values in this zone, will ensure increased use pressure (Kregosky, 1973). Recreational use will continue to be concentrated within this zone and impacts associated with these activities would also be expected to increase. Horse use and elk use in the winter and early spring also exert considerable pressures and the potential for acclerated erosion with this use is quite high. This could have a negative impact on watershed conditions and the potential for damage would be much greater if the area were used for commercial grazing.

Most of the lower slopes within the valley zone, above the North Saskatchewan River, are covered by a silt-loam overlay, which is poorly structured and soft (Pettapiece, 1971; McPherson, 1970). Light traffic disturbs the ground vegetation, and loosens this silt-loam material, resulting in extreme dustiness (Pettapiece, 1971). The continual winds blowing down the North Saskatchewan Valley could enhance the effects of these impacts. The potential for aeolian erosion would be relatively high, due to the fact that silt particles are easily transported. Deposition downstream in the Abraham Lake area would result in increased reservoir sedimentation.

There is some evidence of deterioration resulting from recreational use, along informal trails in the Kootenay Plains Natural Area and on the south side of the North Saskatchewan River, towards Siffleur Falls. Therefore, safeguards are required even in areas where light foot traffic is anticipated. In other areas of the basin, maintenance of good ground cover would be sufficient to minimize this problem. However, due to the semi-arid climate and xeric site conditions, combined with poorly structures soils, vegetation is very fragile and is often difficult to maintain, even under natural conditions.

The valley zone is an excellent ungulate range and sustains a large deer and elk population. The browsing and grazing activities of these animals also disturbs the ground surface. Removal or trampling of fragile vegetation reduces the stability of the soil surface and exposes the fine-textured soils to the effects of aeolian erosion. This situation creates some localized erosion problems, particularly in areas which have been over utilized by ungulates. Portions of the Kootenay Plains Natural Area appear to be particularly susceptible to this type of impact.

Within the Kootenay Plains, infiltration rates are generally high and erosion is not a major problem for undisturbed soils (Pettapiece, 1971). However, soils tend to erode rapidly when disturbed (Pettapiece, 1971). Good watershed conditions are maintained in the Kootenay Plains by providing a high level of protection. The fact that this area is fenced has largely discouraged indiscriminate use and afforded protection from major site deterioration. However, these measures may not be sufficient to prevent deterioration resulting from increased recreational use. Therefore, the erosion potential in this area must be rated as high.

A moderate erosion hazard exists along the banks of the North Saskatchewan River, within the Kootenay Plains area. Peak runoff during the summer results in some streambank erosion; however, the streambanks are generally well stabilized by vegetation. Overstory species such as spruce (Picea glauca) are generally found in these riverine sites in a much higher density than elsewhere in the valley zone, due to the increased availability of moisture. Stream conditions are generally good in other areas of the valley zone. The lower stream bed gradients result in reduced stream velocity and subsequent reduction in fluvial erosion. Stream beds are generally composed of gravels or other coarse materials which are not easily eroded. The braided channel configuration evident in portions of the North Saskatchewan River, upstream from the Kootenay Plains, near the confluence of the Siffleur River, indicates a substantial deposition of eroded materials. Exposed areas of fine-textured silts and sands found over much of the floodplain of the North Saskatchewan River are partially stabilized by moist site conditions, as shown in plate 24. Vegetation has also become established on many of these sites, adding to this stability and further minimizing the erosion potential. However, disturbance of these riverine sites could result in a some deterioration of stream conditions.

A major problem affecting watershed conditions within the valley zone is the fluctuating water level on Abraham Lake, produced by drawdown of the reservoir. Water levels in the spring may be 20m lower than in the fall (Calgary Power, 1973). This leaves large areas of shoreline exposed during spring and early summer. The North Saskatchewan River moves a substantial sediment load and the area of sedimentation would generally correspond to the area

Plate 21: Kootenay Plains Vegetation

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Understory vegetation in the Kootenay Plains consists of loosely-rooted grasses and shrubs, which are highly susceptible to impacts. The silty soil is easily eroded.

Plate 22: Kootenay Plains Vegetation/Soils

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Typical area of the Kootenay Plains. Note the sporadic area of grass/shrub cover and substantial area of exposed soil. The silty soil surface (highly erodible) is shown below:

Plate 23: Kootenay Plains Soil

exposed during low reservoir levels, especially on the upper end of the reservoir (Pettapiece, 1971). This extensive, disturbed area presents some erosion problems during the early spring, when reservoir drawdown is at a maximum. Therefore, management of this shoreline area for erosion control may also be required (Pettapiece, 1971; E.R.F.C.B., 1969).

The slopes immediately above the reservoir in the valley zone also present a moderate erosion hazard, especially on the north side. Some disturbed areas were noted in this area, and there is evidence of erosion on the grass covered slopes, immediately above the reservoir. There is also some evidence of slumpage into the reservoir and evidence of shoreline (wave) erosion along the north-eastern shore of Abraham Lake. Examples of disturbed areas along the reservoir shoreline are depicted in Plate 25. On this basis, some improvement in watershed conditions may be desirable in this area and could be accomplished through site rehabilitation.

Watershed conditions in the valley zone are generally good, with only localized areas requiring erosion control or site improvement at the present time. However, there is a natural deterioration of watershed conditions with existing levels of use. Local damages include gullying, deterioration in species composition (e.g. a decline of fescues and other grasses and the presence of many forbs or herbaceous plants and shrubs), soil compaction from trail use, and other impacts. Increased land use activity may result in deterioration in watershed conditions (Wallis and Wershler, 1981). Therefore, careful planning and the application of appropriate land use guidelines is required.

4.10.4 Watershed Management Guidelines

Management guidelines developed for the valley zone should emphasize watershed protection due to the fragile environment and high potential for watershed damage. Areas such as the grass communities within this zone are very susceptible to impact, with the forested areas being only slightly less sensitive in this regard (Pettapiece, 1971). Portions of the valley zone may be very close to a critical point of deterioration (Wallis and Werschler,1981). Land use within this zone may very easily exceed the low natural carrying capacity, resulting in rapid soil

Plate 24: North Saskatchewan River Floodplain

COLOURED PICTURES
Images en couleur

North Saskatchewan River floodplain in the Kootenay Plains. Note the extensive areas of exposed silts, which contribute to sediment loading in the river. In dry periods, this material is easily transported by aeolian processes. Much of this material is transported by wind and deposited downstream in the reservoir area.

Plate 25: Disturbed Sites Above Abraham Lake

COLOURED PICTURES
Images en couleur

Disturbed areas, such as this site on the west shore of Abraham Lake, present a moderate erosion hazard. Gulley erosion is evident in this site.

erosion. By the time erosion becomes obvious, it may be too late to prevent serious stream sedimentation and subsequent deterioration in water quality. Therefore, preventative measures are required to ensure a high level of watershed protection.

Since land use pressures are likely to increase in the near future, land use controls are urgently required. The fragile environment of this "rangeland" area combined with low and variable productivity, makes it very difficult to control erosion once it has begun (Wallis and Wershler, 1981). On this basis, land use controls provide the most effective methods of limiting erosion. Watershed management guidelines for the valley zone should prohibit expansion of secondary land use activities which have a high potential for damaging this environment. By definition, this may include limitation of hiking, A.T.V. and horse use, which has caused most of the impact to date. The numerous requests to the E.R.F.C.B. and Energy and Natural Resources for ranch development, which have been rejected in the past, must also continue to be denied. Therefore, land management for watershed purposes must have priority within this zone.

Land management flexibility is also required in order to ensure that rehabilitation measures may be applied in response to impacts. Application of site rehabilitation measures may be required to reclaim disturbed areas. For example, rehabilitation measures could be required as a part of road construction or as part of dam operations. Revegetation of road fills, ditches and borrow pits is very important, for erosion control. Similarly, service roads must not be located too close to stream channels, as stream banks are highly susceptible to erosion (Chamberlin, 1982; Kittredge, 1957). The existence of depleted, compacted soils adjacent to the Abraham Lake reservoir or along major streams, compounds the seriousness of erosion problems (Chamberlin, 1982; Pettapiece, 1971).

Fire also presents a serious threat to the forest-grassland community of the valley zone. Removal of grass cover by fire for example, would destabilize an easily eroded surface. The combined effects of wind and overland flow in a burned over area could result in reservoir sedimentation problems. Therefore, a high degree of fire protection is also required in the valley zone. Maintenance of present fire detection/suppression capability within both the valley and intermediate zones should provide an acceptable level of protection.

Where areas of the valley zone are disturbed by fire or other environmental impacts, site improvement may be required. For example, restoration of the ground cover may be required in badly deteriorated sites, in order to improve watershed conditions to an acceptable level. Due to the harsh site conditions, natural vegetation growth may be relatively slow. Therefore, measures such as replanting or reseeding of such disturbed areas, fertilization, or other similar techniques, may have some potential for application, in order to accelerate site recovery.

Phreatophyte control has been suggested as a viable method of improving water yields, in several U.S. studies (Satterlund, 1972; Newhall and Smith, 1965; Kittredge, 1957). However, phreatophyte removal along stream courses in the valley zone and upper North Saskatchewan Basin in general, would be detrimental to the maintenance of watershed conditions appropriate for regime and water quality maintenance or improvement. The root networks of this riparian vegetation contribute to streambank stability and this serves to minimize bank erosion. (Chamberlin, 1982). Removal of riparian vegetation may also result in increased water temperature, due to loss of shade, in direct proportion to the amount of increased sunlight reaching the water surface (Chamberlin, 1982). Increased water temperatures may result in some deterioration of water quality, but this should not be a significant problem in streams in the study area (Chamberlin, 1982; Croft and Bailey, 1964). Maintenance of riparian vegetation is therefore required, in order to minimize erosion and to maintain water quality. Management guidelines must be developed to ensure a high level of protection for these riparian areas. These guidelines could include land use restrictions and other use controls.

Special watershed management guidelines might also be required for the Abraham Lake shoreline. The fluctuating reservoir level results in large mud flat areas being exposed for a considerable portion of the spring and summer months. Increased flow regulation at Bighorn may increase drawdown even further. This could result in a larger shore area being exposed.

Since the area of sedimentation generally coincides with the area exposed during low reservoir levels, removal of accumulated sediments may be required in the future, in order to maintain reservoir capacity (Croft and Bailey, 1964). Bank stabilization measures may also be required to correct and/or prevent slumpage into the reservoir from the slopes above. Land use along the reservoir shoreline may also have to be limited, in order to minimize shoreline impacts and to reduce potential conflicts with reservoir operations.

In summary, watershed management guidelines for the valley zone must emphasize a high degree of protection against erosion. Regulating secondary land uses would be the primary method of minimizing erosion. Limiting potential watershed damage by wildlife and horses is also an important requirement. This area is significant in terms of providing winter and early spring range (and browse) for ungulates, especially elk, but also deer, mountain sheep, goats and wild and domestic horses. Such use will continue to be damaging to watershed conditions but it must also be recognized that this is an important use of the Basin. Therefore, management techniques may have to be considered to make this use more compatible with watershed objectives. Management guidelines must also be developed to ensure the application of both structural and non-structural measures where required, in order to ensure that watershed conditions appropriate for on-site and downstream requirements, are maintained.

4.11 Management Requirements for Optimizing Watershed Objectives

The upper North Saskatchewan Basin is composed of three very different environments, each having a different function in relation to production of streamflow, different watershed management requirements, and different opportunities for improvement with management. All three environments (headwaters, intermediate and valley) are highly inter-related ecologically and therefore, management guidelines must be applied within the basin in a coordinated and comprehensive manner. For example, techniques such as fire control or snow pack management would have very little meaning in relation to the Basin, if these programs were applied only within the intermediate zone. Management guidelines must also reflect the differences in land capability and resource conditions between and within the watershed zones. For example, land use controls may be applied to control impacts within the valley zone. However, the same activity (e.g. backcountry recreation) may have a significantly lower impact in the intermediate zone, due to more stable site conditions. On this basis, management guidelines must be applied generally to the basin. The intensity of restriction, management or rehabilitation measures applied, will largely depend upon local site conditions, the degree of potential impact, and the degree of conflict with maintenance of "ideal" watershed conditions.

In order to realize the watershed management objectives defined for the upper North Saskatchewan Basin, "watershed" must be recognized as a legitimate land use, requiring specific management guidelines. However, application of these watershed management guidelines may have considerable implications for secondary land use. The concept that all resource uses within a given area are in potential conflict, lends credence to this statement. The degree of potential conflict between watershed management and other uses (e.g. wilderness preservation) will depend largely upon the intensity of watershed management required and the degree to which those programs conflict with the philosophy, policy and management strategies associated with each of these secondary uses.

The management guidelines suggested for each zone in the upper North Saskatchewan Basin, would be applied to maintain "ideal" watershed conditions, required to meet the watershed management objectives. This might involve emphasis of watershed objectives at the expense of any significant degree of secondary land use. In practical terms, however, this single-use approach may not be very realistic or appropriate to existing and potential resource demands within this area. Therefore, the requirements and implications of secondary land uses must be taken into consideration and assessed against these "absolute" watershed management requirements. Resource preservation and outdoor recreation, as major secondary uses of the upper North Saskatchewan Basin, have some potential for conflict with management for watershed objectives. The "ideal" land use requirements, philosophies and management implications associated with potential park development, are outlined in Chapter 5. Potential conflicts between watershed management and management for these secondary uses are discussed in Chapter 6.

5. Park Management

5.1 General Background

The upper North Saskatchewan Valley is one of the most scenic valley corridors within the East Slopes region. It is also considerably different from other major river valleys in the East Slopes, most notably the Athabasca, Bow and Crowsnest, because of a general absence of commercial and industrial development. This absence of existing development, combined with high scenic values, presence of provincially significant resources, (e.g. Kootenay Plains) and close proximity to Banff National Park, makes the entire North Saskatchewan Basin study area a potential candidate for provincial park status. The absence of private land holdings and dispositions, existence of marginal forest stands over much of the area, and the absence of recoverable mineral, oil, or gas deposits, also enhances this potential for park status. Establishment of a park in this area would also increase the availability of outdoor recreation opportunities in the central Alberta region (Alberta Recreation and Parks, 1983).

Alberta Recreation and Parks is a major supplier of outdoor recreation and conservation services within the Province. In order to accomplish this mandate, the Department must acquire, develop, and manage appropriate lands as needed (Alberta Recreation and Parks, 1983). To this end, the entire upper North Saskatchewan Basin study area is being considered for reservation, for future establishment as a provincial park (Alberta Recreation and Parks, 1983). Although reservation status does not provide the same degree of resource protection and development control as provincial park status, land use activities and land dispositions are nonetheless strictly controlled, in this interim period. The reservation designation serves three main purposes: 1) To prevent the sale, cultivation, or major surface disturbance (e.g. mines or quarries); 2) To prevent long-term timber and agricultural commitment; and 3) To establish conditions to mitigate the possible negative impacts of such activities as grazing, oil and gas exploration and development, and timber harvesting, in relation to park management objectives (Alberta Recreation and Parks, 1983).

Lands reserved for park purposes in the East Slopes region, are largely protected from land use activities such as grazing, oil and gas development, and timber harvesting, by the East Slopes Policy (1977). The East Slopes Policy provides an outline of land use guidelines, which would be applied in the Basin. Once the area is formally established as a provincial park, more specific land use guidelines would be applied, through the Provincial Parks Act. At present, portions of the Basin are designated as wilderness areas and natural area and these lands are subject to specific use guidelines as defined in the Wilderness Areas, Ecological Reserves and Natural Areas Act, as well as the general guidelines, described in the East Slopes Policy.

However, the reservation of lands and potential establishment of a major provincial park within the upper North Saskatchewan Basin, may have considerable implications on future recreational use in the area. The reservation of lands for provincial park purposes, would also limit the degree to which other land uses could be permitted, due to the land use and development controls inherent in provincial park status.

Although provincial park status ensures the protection of provincially significant resources, such as those found in this area, park status is also a limitation to more intensive use. Much of the existing, extensive recreational use might be limited under park status. For example, park status might result in the prohibition of certain existing recreational activities such as hunting. The degree to which preservation would be encouraged in relation to outdoor recreation, would have a considerable impact upon future recreational use of this area. The mandate of Alberta Recreation and Parks, as defined in the Provincial Parks Act, implies protection from non-parks oriented development, and ensures management for resource protection and outdoor recreation objectives (Provincial Parks Act, 1980). Therefore, resource preservation and outdoor recreation would become the primary uses in this area. On this basis, any potential secondary land uses such as forestry, grazing, mining, and industrial or commercial developments, would be either prohibited or strictly controlled within a provincial park, or on lands reserved for park purposes (Alberta Recreation and Parks, 1983).

Although it is recognized that activities such as haying of native pastures, unimproved grazing, selective timber harvest, and forest, range, water, wildlife and fisheries management are not in conflict with the Departments objectives in reserved areas, as such management activities may enhance potential park and recreation values, such activities would be limited in order to minimize any significant impact on the realization of park management objectives (Alberta Recreation and Parks, 1983). On this basis, the strong resource protection and outdoor recreation emphasis in park management objectives, might also limit the application of large-scale, comprehensive, watershed management programs within the upper North Saskatchewan Basin.

The areas which could be included in this proposed park and potential facility development, will be outlined in this chapter. The management guidelines which would be applied, based on the existing legislation, policies and philosophies will also be evaluated. The potential limitations of park management strategies on watershed management objectives, will also be discussed. It must be recognized that the realization of watershed management objectives, as outlined in chapter 4, will not be entirely precluded by establishment of a provincial park within the basin. However, these objectives could be subordinated in importance, relative to park management objectives.

5.2 Existing Recreational Use and Facility Development

Existing recreational use within the upper North Saskatchewan Basin is generally confined to the North Saskatchewan River Valley. Other areas of the Basin, most notably the Cline Valley, White Goat and Siffleur Wilderness Areas, Pinto Lake, and Landslide Lake areas, are popular for backcountry recreational activities. However, the intensity of recreational use has been steadily increasing in recent years, in both the highway corridor and in backcountry areas (Alberta Recreation and Parks, 1981a).

At the present time, facility development is minimal within the area. Existing development is limited to three small campgrounds and one trail-head staging area, located adjacent to highway 11 (as shown on the fold-out map in the back cover). The three campgrounds, Thompson Creek, Two O'Clock Creek and Cavalcade, are operated by Alberta Forest Service as Forest Recreation Areas. The trail-head staging area is part of the Kootenay Plains Natural Area, which is also operated by Alberta Forest Service. All four areas are very small and only basic facilities such as pit toilets, hand pumps and designated campsites are provided (Alberta Forest Service, 1980). The Thompson Creek campground, located approximately 5 kms east of the Banff National Park boundary contains 37 campsites. The Two O'Clock Creek campground and Cavalcade Group Campground are located approximately 22 kms east of the Banff National Park boundary, on the west side of Highway 11, across from the Kootenay Plains Natural Area. The Two O'Clock Creek Campground contains 20 campsites, while the Cavalcade Group Campground is basically an open field with a capacity for approximately 50 units (Alberta Forest Service, 1980). Use of the Cavalcade Area is restricted to organized groups and is available by reservation only (Alberta Forest Service, 1980). Use of the area is believed to be minimal, based on observations made during the field surveys in the valley zone.

The trail-head staging area, located in the Kootenay Plains Natural Area, consists of a small parking lot and trail access point. This informal trail connects with a foot bridge which crosses the North Saskatchewan River and provides access to the Siffleur Wilderness Area and other lands on the south side of the river. An informal pack trail also runs up the Cline Valley from Highway II to Pinto Lake and has relatively heavy use by local guides and outfitters. Secondary trails branch off this main trail and provide access to the Coral Creek, Cataract Creek, McDonald Creek and Shoe Leather Creek areas. A service centre consisting of a motel, restaurant, gas station and campground is located at Cline River, at the eastern end of the study area, approximately 4 kms north of the point where the Cline River enters Abraham Lake (Alberta Forest Service, 1980).

5.3 Management of Existing Recreational Use

All land within the upper North Saskatchewan Basin is Crown land administered by two provincial government agencies; Alberta Recreation and Parks and Alberta Energy and Natural Resources. Alberta Recreation and Parks currently has jurisdiction over the 445 km^2 White Goat Wilderness Area and the 412 km^2 Siffleur Wilderness Area (Alberta Recreation and Parks, 1981a,b). The management orientation for these Wilderness Areas is outlined in the Wilderness Areas, Ecological Reserves and Natural Areas Act (1981). The Wilderness Areas were established in the late 1960s to preserve their scenic features and natural character and to protect these from impairment, development, or occupation by man (Alberta Recreation and Parks, 1981a). Resource protection is the major management objective within these areas, however, the maintenance of natural processes appears to be the only defined management strategy (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). Although management is clearly oriented toward the maintenance of wilderness values, no active management programs are carried out in these areas.

The remainder of the upper North Saskatchewan Basin is currently administered by Alberta Energy and Natural Resources. The management orientation within this area (with the exception of the Kootenay Plains), might be loosely described as multiple-use, within the context of the zoning guidelines for the 'prime protection' and 'general recreation' zones, as defined in the East Slopes Policy (Alberta Forest Service, 1980; Alberta Government, 1977). Basically, this implies informal recreational use, with no land dispositions and only very limited secondary uses, such as passive wildlife management. The Kootenay Plains Natural Area (plate 26), established in 1968, is managed by Alberta Energy and Natural Resources for preservation of the scenic qualities and unique natural features of this area (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). This area is a candidate for "Ecological Reserve" status (Alberta Recreation and Parks, 1983). This could involve a transfer of administrative responsibility to Alberta Recreation and Parks and result in additional lands being added to this area (Alberta Recreation and Parks, 1983). Ecological Reserves are established and managed to

Plate 26: The Kootenay Plains Natural Area

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The Kootenay Plains Natural Area is highly susceptible to use impacts. The area is fenced to prevent ATV access. Note fence in foreground.

preserve selected examples of the full range of Alberta's natural environmental diversity, for conservation and scientific research purposes (Alberta Recreation and Parks, 1982; Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981).

Two objectives are emphasized in the management of lands within the upper North Saskatchewan Basin. Resource protection is the primary management objective within the White Goat and Siffleur Wilderness Areas and Kootenay Plains Natural Area. Outdoor recreation is apparently the primary management objective for other lands within the study area. Secondary objectives might include management of forest, range, water, wildlife and fisheries. However, no active management programs are carried out. Management is essentially limited to the provision of resource protection, accomplished through restriction of land uses such as mining, forestry, oil and gas exploration, industrial developments and agriculture.

5.4 Potential for Park Development

5.4.1 Resource Significance

The upper North Saskatchewan Basin contains numerous unique, natural features, many of which could be considered as provincially significant resources (Kregosky, 1973). For example, the Kootenay Plains area is a particularly significant representation of a montane natural area. (Alberta Recreation and Parks, 1983). Although the best known resources include those found in the Kootenay Plains area, other unique features are present in the more remote and relatively undisturbed areas of the Basin as shown in figure 7. Some of the scenic qualities of the study area are illustrated in plates 27 to 31. In recent years, various proposals have been put forward by several different interest groups and concerned individuals, advocating legislative protection of significant resources found outside of the existing Wilderness Areas and Natural Area.

In 1973, the Alberta Wilderness Association advocated the establishment of two additional wilderness areas within the Basin; the Whiterabbit Creek sub-basin and the portion

FIGURE 7
SIGNIFICANT NATURAL FEATURES

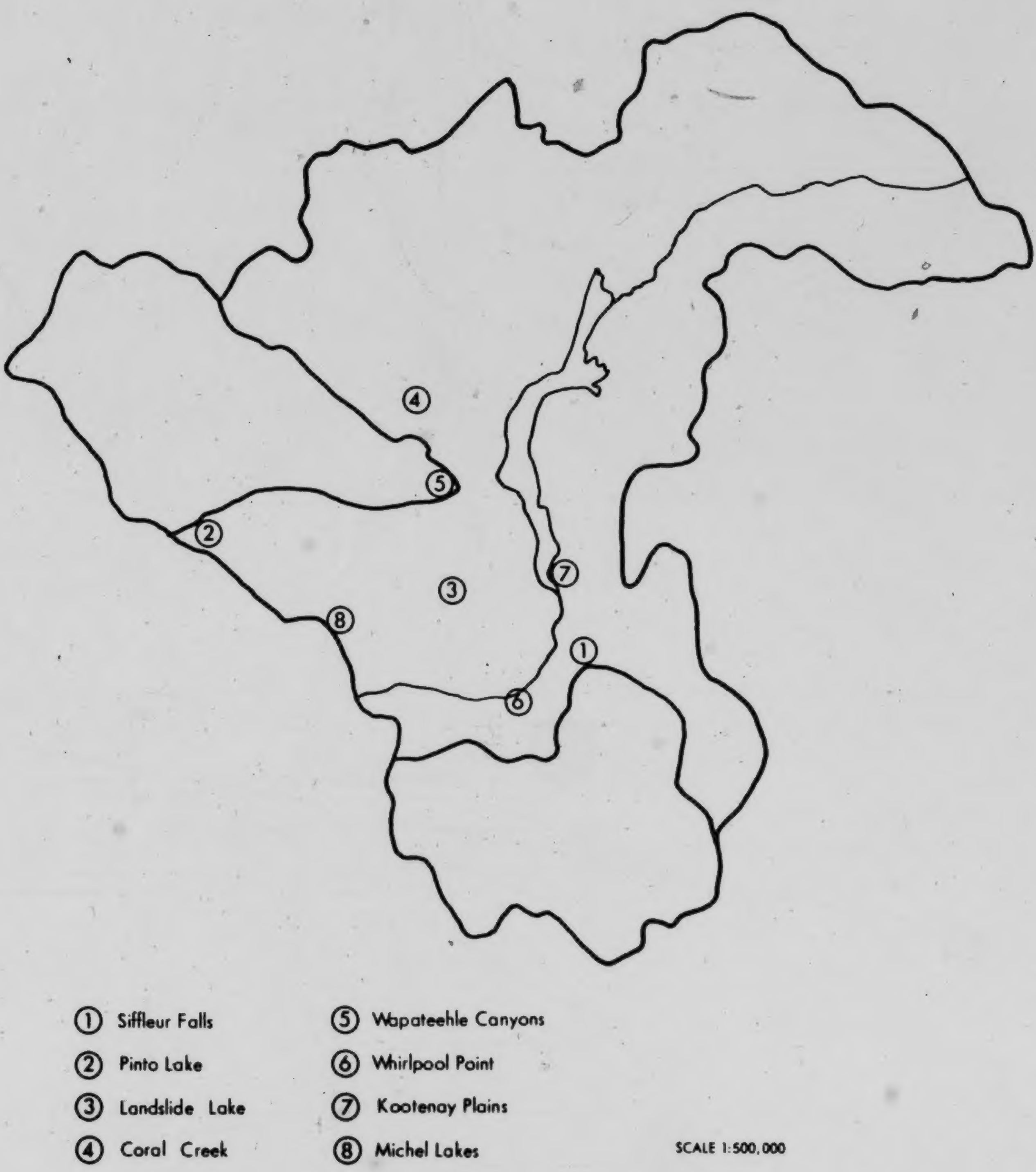

④
⑤
②
⑦
③
⑧
①
⑥
① Siffleur Falls
② Pinto Lake
③ Landslide Lake
④ Coral Creek
⑤ Wapateehle Canyons
⑥ Whirlpool Point
⑦ Kootenay Plains
⑧ Michel Lakes
SCALE 1:500,000

Plate 27: North Saskatchewan River at Whirlpool Point

COLOURED PICTURES
Images en couleur

Whirlpool Point (above) is a rock outcrop in the North Saskatchewan River which splits the flow, resulting in rapids, due to the increased flow velocity. Whirlpool Point also marks the point where the North Saskatchewan Valley swings abruptly north from its previous east-west direction.

Plate 28: North Saskatchewan River Valley - Near Whirlpool Point.

COLOURED PICTURES
Images en couleur

Plate 29: North Saskatchewan River Valley - Near Kootenay Plains

Plate 30: Abraham Lake - Looking Upstream from the Bighorn Dam.

COLOURED PICTURES
Images en couleur

Plate 31: Small Tributary Stream - Cline Sub-Basin

of the Cline sub-basin deleted from the White Goat Wilderness Area in the early 1970s (Alberta Wilderness Association, 1973). The A.W.A. proposed designation of the Whiterabbit sub-basin as a Wilderness Area to protect the natural conditions, wildlife values, and significant resources (Alberta Wilderness Association, 1973). It was suggested that this could be accomplished through a single-use reservation for wilderness purposes, with essentially all other land uses being precluded (Alberta Wilderness Association, 1973).

Kregosky (1973) advocated provincial park status for all lands lying north of Highway 11, presently excluded from the White Goat Wilderness Area. Several unique natural features were identified in this area, including waterfalls, canyons, caves and small glaciers (Kregosky, 1973). The two main features of this area are the Landslide Lake rock slide and the canyon complex of the Cline River and its tributaries (Kregosky, 1973). The canyon area is described as being unique because three such canyons are found in a localized area and display a wide range of geological features (Kregosky, 1973). The un-named first creek drainage, west of Mount Cline contains at least five waterfalls along its 12 km course, with the major falls comprised of a 150m vertical cascade, worn over the cliff face (Kregosky, 1973). Landslide Lake consists of a small, rock slide dammed lake covering approximately one hectare (Alberta Wilderness Association, 1973). This lake has high scenic value and is located in a relatively undisturbed area. The area at the confluence of Coral Creek and the Cline River also contains a spectacular canyon and several small waterfalls. The Coral Creek canyon also contains some "Hoodoos" features (Alberta Wilderness Association, 1973). Kregosky advocated Natural Area status for this canyon area, identified as Wapateehk Canyons, based on the high scenic values and perceived significance of these features (Kregosky, 1973).

The Pinto Lake area also has some geological significance, due to its spring fed origin (Kregosky, 1973). Pinto Lake is already well known as a good fishery and because of the ease of access afforded by the existing, informal trails, use is relatively heavy at the present time. It could be logically argued that relative ease of access from Highway 11 to other significant areas, such as Landslide Lake and the Cline Valley and tributary valleys such as Coral Creek, Boulder

Creek and Entry Creek, could result in increased use in these areas in the near future. Some evidence of overuse was noted in the Pinto Lake area during the field surveys. The potential for environmental deterioration with existing recreational use in other parts of the basin is also apparent. Various options for protecting lands from deterioration should be considered. Inclusion of this area as a provincial park would be one option for providing resource protection through legislation and would also provide for controlled recreational use. Control of recreational use would help to provide adequate protection of these unique natural resources. Other land designations or prohibition of land uses through regulation, are also potential alternatives. The aesthetics of this area are further enhanced by the absence of other land disturbances, such as seismic activity, mining or forest operations (Kregosky, 1973). On this basis, provincial park status could provide for the maintenance of the natural character of this area. The low potential for resource development enhances the suitability of this area for designation as a provincial park. The capability of this area to sustain dispersed recreational activities, permitted within a provincial park, such as hiking, backcountry camping, fishing or riding, could be rated as moderate (Kregosky, 1973). Such activities could be accommodated in this area, with only minimal facility development.

The Kootenay Plains Natural Area includes some 24 km^2 of the North Saskatchewan River Valley. This area is considered to be representative of the Rocky Mountain Montane Natural Region and is the most extensive northern outlier of this zone (Wallis and Wershler, 1981). This area also contains a large number of special features and representative landscapes (Wallis and Wershler, 1981). The Kootenay Plains provides a sharp contrast to other natural features found within the Basin, such as the sub-alpine forest zone, characteristic of the Siffleur and White Goat Wilderness Areas. Designation of the Kootenay Plains as an ecological reserve could result in additional grassland areas being protected. This additional area might include significant areas northwest of Highway 11 (Alberta Recreation and Parks, 1983).

The significance of natural resource features within the upper North Saskatchewan Basin combined with high scenic values, makes this area desirable for designation as a provincial park. In addition to providing adequate protection for resources outside of the existing Wilderness Areas, and Natural Area; the designation of lands as a provincial park would provide an effective buffer around these areas. This would essentially consolidate all land within the Basin as either provincial park, natural area or wilderness area and would provide for maximum resource protection.

5.4.2 Land Capability for Outdoor Recreation

Several researchers have assessed the recreational carrying capacity of the North Saskatchewan River Valley, between the east boundary of Banff National Park and the Bighorn Damsite. Pettapiece (1971) completed a soil classification oriented land capability assessment for outdoor recreation, while Frechette (1970) and Benfield (1974) evaluated the recreational land use capability of the Abraham Lake shorelands.

Pettapiece (1971) completed a recreational carrying capability assessment as part of a comprehensive soil inventory and physiographic classification of land units within the North Saskatchewan River Valley. Several recreation capability classes were developed on the basis of the potential intensity of outdoor recreational use or the quantity of outdoor recreation which may be generated and sustained per unit area of land (Pettapiece, 1971). Seven land capability classes were advanced, ranging from 1 (very high capability) to 7 (very low capability), with 5 increments within this range (Pettapiece, 1971). Nine recreation capability sub-classes were also utilized to identify the kind of features which provide opportunities for different outdoor recreation activities (Pettapiece, 1971). These sub-classes were designated as E. vegetation, F. waterfalls and rapids, K. organized camping, L. landforms, M. small surface waters, O. upland wildlife, Q. topographic variation, S. skiing area, and V. view (Pettapiece, 1971). By combining the class and sub-class, Pettapiece rated a unit of land on the basis of its capability to sustain a given activity or group of activities. For example, an area such as the west facing slopes of Sentinel Mountain and Elliot Peaks, could be rated a 2-S/Q/V, which would translate into a high capability for ski area development, good topographical variation and high view or scenic qualities (Pettapiece, 1971).

Pettapiece also noted a general trend in the capability of lands for outdoor recreation. Generally speaking, the recreation potential of the area is shown to be low in the mountains, increasing to moderate in the valleys with small localized areas of higher potential (Pettapiece, 1971). Although the general area can attract large numbers of users due to the scenic qualities, the climate, vegetation and soil conditions preclude intensive development, without risk of the loss of vegetative cover, and subsequent soil erosion (Pettapiece, 1971). Therefore, the area could provide a high quality environment for extensive recreation to a moderate number of users (Pettapiece, 1971). Potential activities within the area could include hiking and camping as well as viewing scenery, with some potential for downhill ski developments in the Sentinel Mountain/Elliot Peaks area of the Cline sub-basin (Pettapiece, 1971).

Frechette (1970) and later Benfield (1974) assessed the recreational carrying capacity of the Abraham Lake reservoir and shorelands. The Frechette study provided an assessment of the recreational potential of these shoreland areas, as related to the physical characteristics of the reservoir and surrounding shorelands (Frechette, 1970). The Abraham Lake reservoir has only a minimal capacity for recreation (Frechette, 1970). The fluctuating water levels could create hazards to boating during low supply levels, due to submerged rocks and other debris. Launching of boats is also difficult, due to fluctuating water levels. These problems are further compounded by the continual and frequently high winds blowing down the North Saskatchewan River Valley.

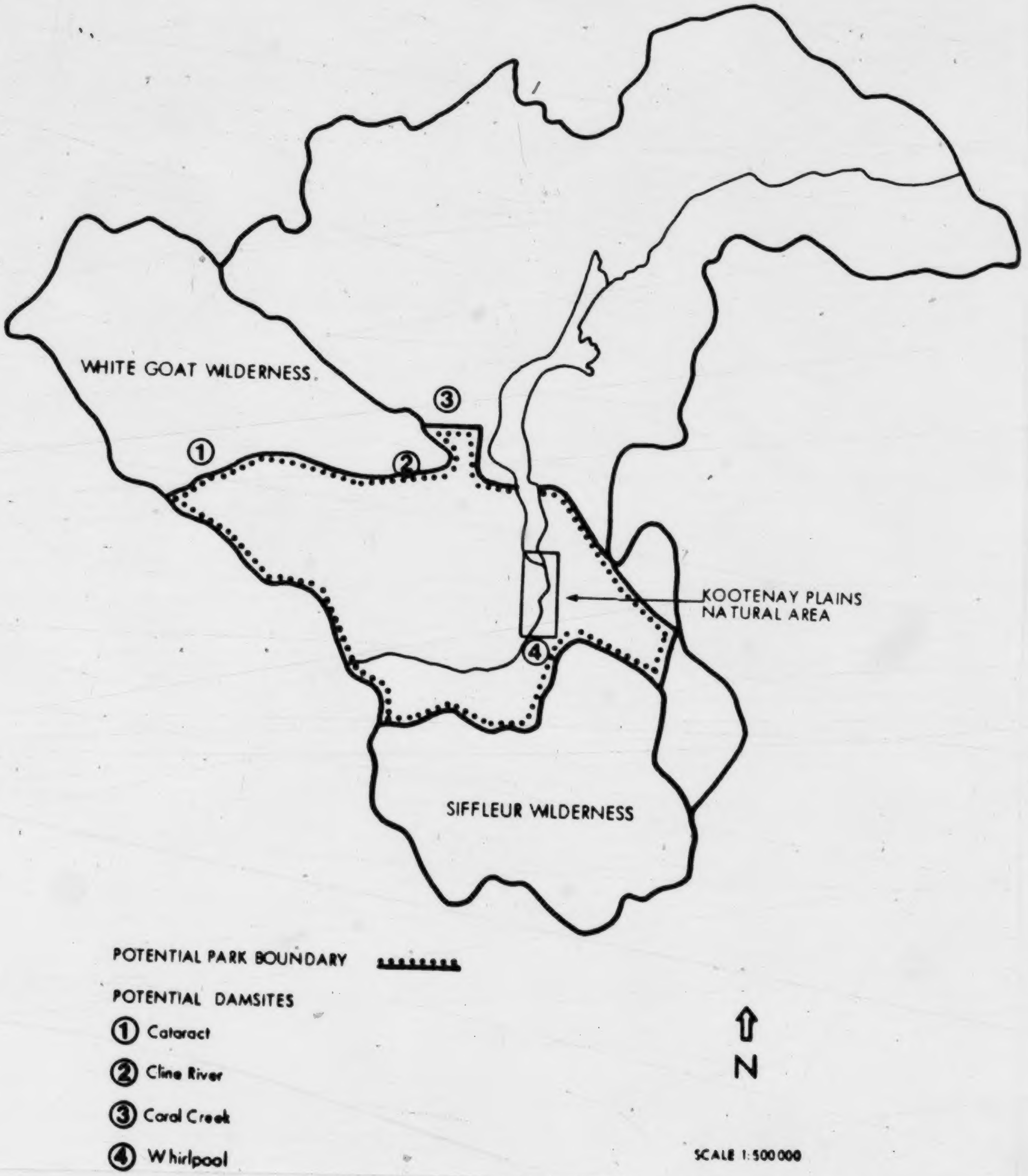
Although the reservoir is rated as having only a minimal capability to support outdoor recreation, the site aesthetics are enhanced by the presence of the reservoir at full supply level (Frechette, 1970). Although the mountain and lake scenery enhance site aesthetics and increase the number of potential users, the large exposed mudflats, visible during low supply levels for much of the year, significantly detract from site aesthetics and lower the recreational capability of the surrounding area (Benfield, 1974; Frechette, 1970).

The potential for increased flow regulation at the Bighorn Dam may result in increased drawdown, extending the low supply period and detracting further from the scenic qualities of Abraham Lake and the surrounding area (Alberta Environment, 1982). From a park management perspective, it would be highly desirable to alter the management and power generating plans for the Bighorn Dam, in order to improve site aesthetics and thereby enhance the recreational capability of the surrounding area. However, this could conflict with the economic operation of the dam relative to meeting downstream demands for increased pollution abatement and power production capability, but some possibilities might exist for maintaining a high water level during the main summer travel period, to improve site aesthetics. Therefore, it may be possible to balance some degree recreational capability with water supply/power production capability.

5.4.3 Potential Park Boundaries

Establishment of a provincial park in the North Saskatchewan River Valley would effectively consolidate all lands in the study area into a single management unit (See Figure 8). Due to the resource significance of areas lying west of Highway 11 and the significance of the Kootenay Plains area, the park area should include all land lying between the White Goat Wilderness Area to the north and Siffleur Wilderness Area to the south and extending west to the Banff National Park boundary. The Provincial Park should also extend eastward to the point where the Cline River enters Abraham Lake, with the Cline River providing a natural, well-defined east boundary. It would also seem probable that the area surrounding Wapateehk Canyons, as identified by Kregosky at the Coral Creek/Cline River confluence, would also be included in any potential park based on the significance of this canyon complex. The park boundary should also exclude the site of the proposed Odyssey resort, on the south side of the Cline River, at the point where it enters Abraham Lake. On the east side of Abraham Lake, the mountain range northeast of Whiterabbit Creek would provide a well-defined boundary and would permit inclusion of the mouth of the Whiterabbit Valley in the park. The remainder of

FIGURE 8
POTENTIAL PROVINCIAL PARK BOUNDARIES


WHITE GOAT WILDERNESS
①
②
③
④
KOOTENAY PLAINS NATURAL AREA
SIFFLEUR WILDERNESS
POTENTIAL PARK BOUNDARY
POTENTIAL DAMSITES
① Cataract
② Cline River
③ Coral Creek
④ Whirlpool
⇧ N
SCALE 1:500 000

the Whiterabbit watershed may be desirable for establishment as a wilderness area as advocated by the Alberta Wilderness Association. Alternatively, this area could be designated as a controlled buffer zone, as defined under the Wilderness Areas, Ecological Reserves and Natural Areas Act. This would also provide legislative protection from development, while permitting activities such as hunting and fishing (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). However, allocation of lands to such restrictive, single uses may not be the best use of these lands.

The area described in this estimate of lands to be included in a potential park represents some 34,400 hectares or 344 km^2. Although no actual boundaries have been announced by Alberta Recreation and Parks, the areas suggested by the author of this thesis for possible inclusion are based on the assumption that the existing north and south boundaries with the Wilderness Areas and west boundary with Banff National Park would be maintained. Secondly, it would be desirable to have a well-defined eastern boundary, which would permit the inclusion of the majority of significant resources, while not conflicting with existing land use. On this basis, the Cline River is suggested as a possible boundary, as this would not conflict with existing operations of guides and outfitters in the Cline Valley, east of the river. It is also probable that the site of the Odyssey project would also be excluded from the proposed park, based on the fact that it would be a pre-existing disposition and a potentially conflicting land use. The potential park boundaries outlined in this chapter would serve to consolidate all lands between the Wilderness Areas and surrounding the Kootenay Plains Natural Area into a single management unit under the administrative control of Alberta Recreation and Parks. This would protect resources such as the Kootenay Plains, Pinto Lake, Landslide Lake, Whirlpool Point, Coral Creek Canyon, and other features. However, these resources could also be protected by other agencies, other land designations or different management guidelines.

5.4.4 Potential Facility Development

Since part of the mandate of Alberta Recreation and Parks is to provide facilities for outdoor recreation, it is logical to assume that facilities to accommodate camping, day use and dispersed backcountry recreation activities could be developed, following establishment of this park. Although the scale of facilities developed could range from a minimal level to intensive, large-scale development, no plans have been released by Alberta Recreation and Parks to date. In addition, it is probable that any such developments (and actual establishment of a provincial park) would not occur for at least five to ten years (Edmonton Journal, Nov. 5, 1981).

Site conditions in the upper North Saskatchewan Basin might limit the extent of facility development possible. Several constraints to intensive development were noted by Pettapiece, in his land capability assessment for outdoor recreation (Pettapiece 1971). Specifically, land capability for intensive recreational use is generally low in upland areas, due to topographic constraints, with lower valley areas having a moderate capability for outdoor recreation (Pettapiece, 1971). On the basis of these physical limitations to facility development, it would be logical to assume that any intensive development (excluding ski areas) would be confined to the North Saskatchewan River Valley, outside of the Kootenay Plains Natural Area. This could imply an expansion of the existing Alberta Forest Service campgrounds at Thompson Creek and Two O'Clock Creek, additional facility development in this western portion of the valley and on the west side of the highway, north-west of the Kootenay Plains Natural Area. Campground and day use facilities located within the valley corridor would also provide a logical staging area for dispersed backcountry recreational activities, such as hiking, riding, etc. which could take place in the upland areas of the park and in the adjacent Siffleur and White Goat Wilderness Areas. Potential facility development in the upland areas would likely be limited to trail construction and possibly road access to resources such as Pinto Lake and Landslide Lake. Therefore, the general pattern of recreational facility development would emphasize intensive development along the transportation corridor, in the North Saskatchewan Valley (except for the Kootenay Plains). Dispersed recreation and minimal facility development would be emphasized in adjacent areas. In the long-term, development in the valley area could possibly include serviced auto-access camping (perhaps four to five hundred campsites), extensive day use picnic facilities, fixed-roof accommodation, hostels, viewpoints, interpretive displays, administrative and visitor services facilities and trail heads providing access to other areas of the Basin. Dispersed recreation would include all backcountry activities presently permitted within a provincial park. These activities could include hiking, fishing, cross-country skiing and backcountry camping. A.T.V. use and hunting are excluded by existing policy. Development of a downhill ski facility in the Sentinel Mountains/Elliot Peaks area would largely depend upon future demand in the region and on the development of the Odyssey project. Demand for such a facility may be relatively low at present, due to intervening opportunities in other areas of the East Slopes. Snow conditions in this area may also make development of this site questionable without snow making (Janz and Storr, 1977; E.R.F.C.B., 1969). However, potential development of this site is still a possibility in the future. Should this development occur, road access would have to be provided through the Cline Valley and this would likely increase facility development in the area adjacent to this roadway.

5.4.5 The Odyssey Project

In addition to the potential for development of a major provincial park in the study area, a resort complex known as the Odyssey, will likely be constructed in the near future (Alberta Environment, 1982). Incorporating some 400 hectares, the site of the project is bounded on the north by the Cline River, on the east by the David Thompson Highway, on the south by the 10th baseline and on the west, by the pre-1973 (original) boundary of the White Goat Wilderness Area (See plate 32) (Van Dyke, 1973). Facilities would include a 300 room hotel complex, an 18 hole golf course and related facilities such as swimming pools, tennis courts, riding stables and staff accommodation (Edmonton Journal, July 20, 1982b; Van Dyke, 1983). Approximately 140 hectares of the site would be utilized for the buildings and related recreational facilities, with the remaining 260 hectares forming a buffer zone between the resort and the surrounding area (Van Dyke, 1973). Equestrian and cross-country ski trails might also be developed with in this buffer zone (Van Dyke, 1973). Although the Development Appeal Board (D.A.B.) has recently approved construction of the Odyssey project, various environmental groups are appealing this decision on the basis that irreparable environmental damage will result to the "wilderness" character of the area (Edmonton Journal, July 20, 1982b). Although it is difficult to assess the potential environmental impacts of the Odyssey, it nonetheless remains a controversial issue and is a good example of the potential conflict between preservation and development.

5.5 Natural Resource Conservation - Outdoor Recreation Management Objectives

The resource management orientation for the upper North Saskatchewan Basin is essentially defined by the zoning guidelines identified in the East Slopes Policy and by legislation pertaining to the specific designation or status of land within the zoning framework. In the East Slopes Policy, broad units of land or management zones are identified, management objectives for each zone are specified and the broad types of uses which can be permitted within each management zone are outlined (Alberta Government, 1984; 1977). The management zones theoretically provide for the resolution of land use conflicts; however the primary purpose is to allocate resources on a regional scale (Alberta Government, 1977). On this basis, all lands within the study area are allocated essentially to resource preservation and outdoor recreation uses. Establishment of a large provincial park in the upper North Saskatchewan Basin would be consistent with this land allocation, assuming that fire control policies and the degree of park development are compatible with the East Slopes Policy guidelines. Once these lands are designated as a provincial park, the Provincial Parks Act provides more specific management direction, within the overall general guidelines established under the East Slopes Policy. Similarly, the Wilderness Areas, Ecological Reserves and Natural Areas Act outlines more specific management guidelines for the wilderness areas and the Kootenay Plains, within the overall zoning guidelines specified in the East Slopes Policy.

Plate 32: Site of the Odyssey Resort.

COLOURED PICTURES
Images en couleur

Part of the Odyssey resort site is shown at left, overlooking the Cline River and Abraham Lake. The reservoir is shown at full supply level, in the late fall.

5.6 Compatibility of Potential Developments with the East Slopes Policy

The developments proposed for the upper North Saskatchewan Basin, such as the Odyssey project, intensive development of park facilities in the valley corridor and management of extensive recreation in adjacent areas, are consistent with the East Slopes Policy zoning guidelines. Three management zones are identified within the upper North Saskatchewan Basin study area in the East Slopes Policy. The valley corridor, adjacent to the David Thompson Highway, is zoned as 'general recreation' (Alberta Government, 1984, 1977). This small zone extends approximately 2 to 5 kms outward from the north side of the highway between the east boundary of Banff National Park and the eastern boundary of the study area. The general recreation zone also extends 1 to 2 kms south of the highway, between the east boundary of Banff National Park and Whirlpool Point, as shown in Figure 9. The remainder of the study area, which would include most of the proposed provincial park, the Kootenay Plains Natural Area and Siffleur and White Goat Wilderness Areas is zoned as 'prime protection' for significant resources, wildlife and watershed (Alberta Government, 1977). The site of the Odyssey project has been zoned as a small 'facility zone' obviously with the intention of encouraging development of this site, as such developments would not be possible on lands zoned as either 'general recreation' or 'prime protection' (Alberta Government, 1977).

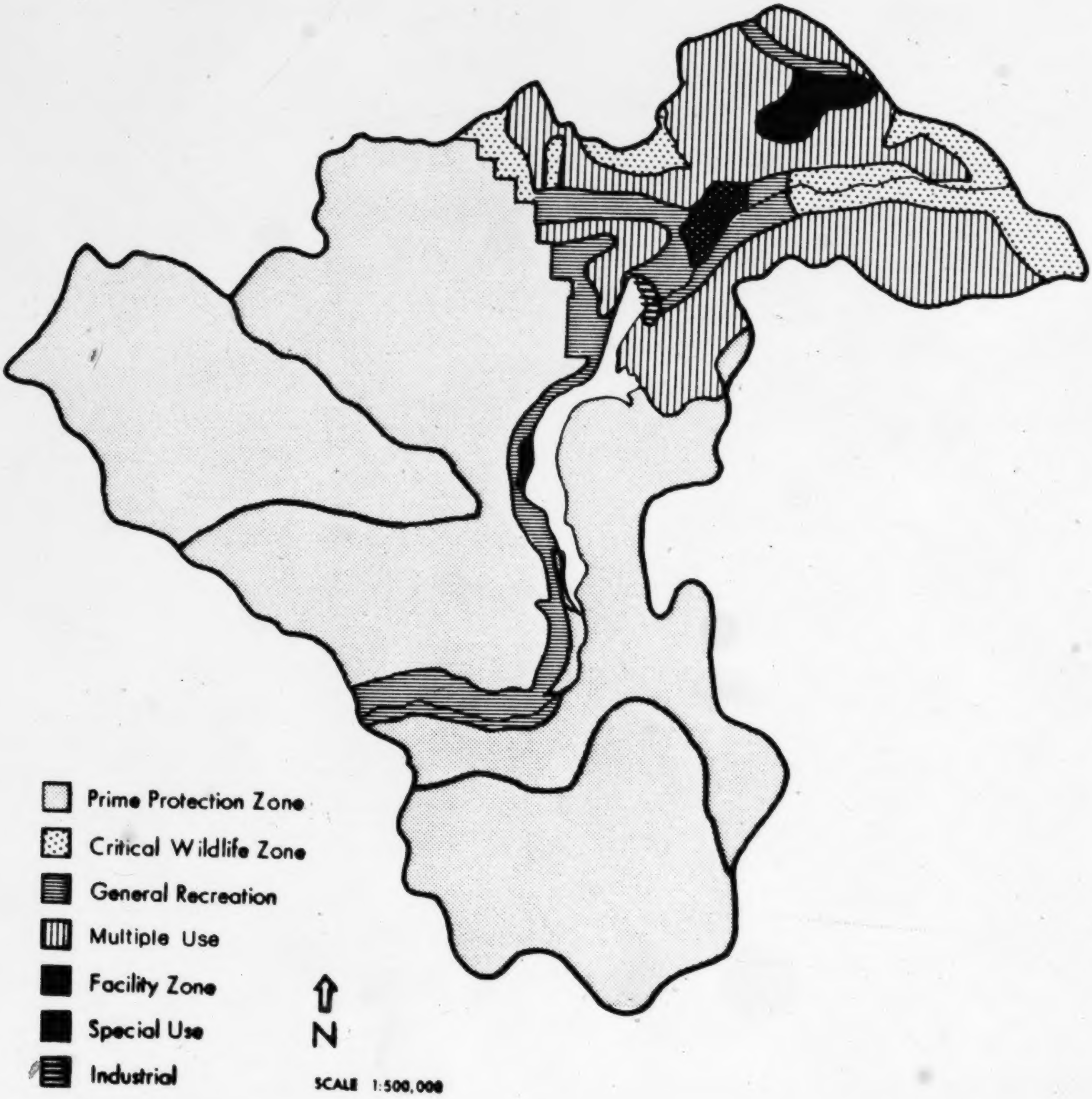
5.7 East Slopes Policy Management Objectives and Guidelines

The zoning guidelines identified for the upper North Saskatchewan Basin study area in the East Slopes Policy, outline management strategies for the various zones. The management objectives and guidelines specified in the East Slopes Policy are summarized for each of the three zones applicable within the study area; 'general recreation,' 'prime protection,' and 'facility.' The general recreation zone includes lands required to ensure the retention of a variety of natural environments for outdoor recreation purposes and to provide for a wide range of dispersed and concentrated outdoor recreation activities within a natural setting (Alberta Government, 1977). Therefore, development of intensive recreational facilities within the North Saskatchewan Valley corridor, as part of a new provincial park, would appear to be consistent with the East Slopes Policy.

Management of the general recreation zone would emphasize maintenance of the natural environment for recreational use (Alberta Government, 1977). In order to accomplish this objective, resources may be managed or manipulated to maintain the recreational carrying capacity of lands within this zone (Alberta Government, 1977). In order to ensure recreational carrying capacity is maintained, the management guidelines, established for this zone, prohibit cultivation and industrial development (Alberta Government, 1984). Grazing, petroleum, natural gas or mineral exploration and development and forestry operations would be strictly controlled (Alberta Government, 1984). The East Slopes Policy also contains specific guidelines applicable to the general recreation zone within the study area. The valley area adjacent to Abraham Lake, and other areas adjacent to the David Thompson Highway corridor, are intended to serve as access nodes to the wildland areas included in the prime protection zone (Alberta Government, 1977).

Within the prime protection zone, the stated management objective is to preserve the environmentally sensitive terrain and the valuable aesthetic resources of the East Slopes Region (Alberta Government, 1977). Watershed protection, and the preservation of rare or fragile biotic communities, are also of paramount concern within this zone (Alberta Government, 1984). On this basis, land use within the prime protection zone would be strongly oriented toward dispersed 'backcountry' recreation activities, such as hiking, fishing or other such non-mechanized forms of recreation (Alberta Government, 1977). Potential management programs within this zone are also very limited. Where considered essential, management programs may include fire control, wildlife habitat improvement and sanitation cutting (Alberta Government, 1977). However, wildlife habitat improvement would generally be accomplished by means of controlled burning or fertilization programs, rather than aesthetically unattractive mechanical means, while fire control and sanitation cutting would be permitted only where there is a proven hazard to merchantable timber outside the zone (Alberta

FIGURE 9
EAST SLOPES ZONES


Prime Protection Zone
Critical Wildlife Zone
General Recreation
Multiple Use
Facility Zone
Special Use
Industrial
N
SCALE 1:500,000

SOURCE: EAST SLOPES POLICY-1977

Government, 1977). No serviced camping would be provided. Development of trail systems for hiking and equestrian use may also be strictly controlled in some areas (Alberta Government, 1977). The emphasis placed upon dispersed backcountry recreation within areas surrounding the North Saskatchewan Valley corridor (general recreation zone), as indicated by the land capability assessment and potential park development, would be consistent with these policy guidelines.

Land use activities which are not permitted within the prime protection zone include mineral, petroleum and natural gas exploration and development, and all-terrain vehicle use (Alberta Government, 1977). Commercial development, roadways and utility corridors would normally be precluded; however certain exceptions are possible (Alberta Government, 1984, 1977). For example, future commercial ski developments may be permitted in the prime protection zone, since it contains the only potentially suitable snow and terrain conditions within the East Slopes (Alberta Government, 1984, 1977). Roadways and utility corridors would also be required to service any ski areas. Development of the potential ski area in the Sentinel Mountains/Elliot Peaks area, as identified in the Pettapiece land capability assessment, would be possible under the policy guidelines for the prime protection zone (Pettapiece, 1971).

Existing and potential commercial developments, as well as lands designated to accommodate intensive developments required for outdoor recreation purposes in the East Slopes, are usually in a facility zone catergory (Alberta Government, 1977). A small facility zone is located within the study area, adjacent to Abraham Lake. This is the future site of the Odyssey resort complex. Therefore, the intent of this zone within the study area is to provide visitor accommodation services. Although it is recognized that compatible land uses vary within any facility zone, depending upon the requirements of the specific developments, certain land use activities are precluded. Mineral exploration and development, and hunting are prohibited, while several other land use activities such as forestry operations, grazing and industrial development are restricted (Alberta Government, 1984).

In the East Slopes Policy, management objectives and guidelines are defined for all land use activities within the East Slopes Region. Analysis of the zoning and related guidelines applied to the upper North Saskatchewan Basin through this policy, clearly indicates a strong emphasis of outdoor recreation objectives. For example, the management objectives for the facility and general recreation zone clearly emphasize both intensive and dispersed recreation, while a major objective within the prime protection zone is to ensure that land use is oriented toward dispersed backcountry recreation. (Alberta Government, 1977).

In addition to the management objectives embodied in the East Slopes Policy, existing legislation also defines the management orientation for areas of the upper North Saskatchewan Basin, under the jurisdiction of Alberta Recreation and Parks. If a major provincial park were established within the study area, as described in this chapter, administrative control of the remaining areas would be transferred from Alberta Energy and Natural Resources, to Alberta Recreation and Parks. The management orientation would also change. Basically, the limited "multiple use" orientation, applied within the context of the East Slopes Policy guidelines and existing legislation by Alberta Energy and Natural Resources, would be replaced by the outdoor recreation and conservation orientation of Alberta Recreation and Parks.

The Provincial Parks Act would initially define the management orientation to be applied within the new provincial park, while the Wilderness Areas, Ecological Reserves and Natural Areas Act would define the management orientation for the Kootenay Plains and Siffleur and White Goat Wilderness Areas. The purpose of parks as stated in the Provincial Parks Act is to conserve and manage flora and fauna; to preserve specified areas and objects therein, that are of geological, cultural, ecological or other scientific interest, and to facilitate their use and enjoyment for outdoor recreation (Provincial Parks Act, 1980).

The management objectives for wilderness areas, ecological reserves and natural areas are also strongly oriented toward preservation, with dispersed recreation being permitted, but on a limited basis, with certain activities such as fishing, equestrian use and motorized vehicle use being prohibited (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981).

Wilderness areas have been established to preserve areas of land in a natural state, unspoiled by man, while ecological reserves have been established essentially to preserve significant ecological resources, which are representative of a physiographic zone within Alberta. In both cases, the management strategy is oriented toward preserving the environmental integrity of these areas by allowing natural processes to continue unimpeded by man. Within these areas, management programs may only be considered for the management, preservation, or protection of animal and plant life (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). In conjunction with the emphasis placed on resource protection in these areas, no land disposition, undertaking, structure or man-made works will be permitted (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). In addition, no licence, interim licence or permit shall be issued under the Water Resources Act for any diversion, undertaking or works within any wilderness area or within any controlled buffer zone. (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). In order to provide for the protection of wilderness areas, the Minister of Alberta Recreation and Parks may designate by regulation, any area of public land adjoining a wilderness area or ecological reserve as a controlled buffer zone (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). Within the upper North Saskatchewan Basin, there are two areas with some potential for designation as controlled buffer zones; the portion of the Cline River sub-basin, excluded from the proposed provincial park, but originally part of the White Goat Wilderness,and the Ram-Whiterabbit sub-basin, adjacent to the Siffleur Wilderness Area.

The eastern portion of the Cline sub-basin, containing the Cataract Creek, McDonald Creek, Boulder Creek and Coral Creek watersheds, was deleted from the original White Goat Wilderness Area in 1973, because traditional recreational activities such as hunting, fishing and equestrian use were prohibited under the Wilderness Areas Act (Alberta Wilderness Association, 1973). Designation as a controlled buffer zone would permit these activities to occur, but would prevent any development within the area. This is desirable from a wilderness management perspective in both the Cline and Whiterabbit areas, since potential development appears to be the main threat to environmental conditions within these areas. Therefore, in order to preserve the environmental integrity of these areas, future water resource developments (and other developments) are, by necessity, precluded within any area designated as a controlled buffer zone (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981).

6. Potential Watershed Management - Park Management Conflicts

6.1 Background

Potential watershed management and park management objectives have been defined for the upper North Saskatchewan Basin in Chapters 4 and 5 of this thesis. However, the management strategies required to attain the environmental conditions necessary to meet these two different sets of objectives, are not always compatible. Both management strategies cannot be applied simultaneously within the Basin, without some potential for conflict. The application of one management strategy may either limit, or prevent the attainment of environmental conditions, required to realize the other set of objectives. This will influence the degree to which one set of objectives may be emphasized in relation to the other set of objectives. For example, the application of a management strategy appropriate to meeting park management objectives, may limit or restrict the degree to which lands can be managed to meet watershed management objectives. Similarly, the degree to which park management objectives could be optimized under a management strategy appropriate to meeting watershed objectives, would also be limited. It is therefore necessary to assess both the short-term and long-term implications of each management strategy, in order to determine the type, level and nature of potential management conflicts between different uses.

Since both sets of management objectives cannot be simultaneously maximized, it will be necessary to select either one strategy over the other or; to select a strategy which incorporates some combination of guidelines from both strategies. This balancing of objectives may permit the attainment of portions of both sets of objectives. The degree to which one set of objectives (e.g. watershed) may be realized, would depend upon the degree to which the other set of management objectives (e.g. park) is to be emphasized, at a particular point in time.

Comprehensive planning is required for the Basin, in order to integrate these and other uses, and to develop appropriate management strategies. The first stage in such a process would be to identify potential conflicts between the watershed management objectives and park management objectives outlined in chapter 4 and 5.

The objective of the author in this chapter is to identify potential limitations to watershed management resulting from management of the upper North Saskatchewan Basin for park purposes. The potential limitations for park management will also be discussed. This evaluation of potential management conflicts will be based upon an assessment of the limitations to watershed management, implied by the East Slopes Policy and existing legislation, such as the Wilderness Areas, Ecological Reserves and Natural Areas Act. These limitations will then be compared with potential watershed objectives and requirements outlined for the study area, in chapter 4. Additional limitations to watershed management, implied by the possibility of provincial park development in the study area, will also be evaluated. On this basis, a full assessment of potential watershed management and park management conflicts can be completed.

Three levels of potential management conflicts can be identified within the upper North Saskatchewan Basin; general limitations, zone specific conflicts and site specific conflicts. General limitations apply to the Basin as a whole. These limitations are implied by the general policy statements contained in the East Slopes Policy. For example, the land use and management guidelines identified for the prime protection zone, in the East Slopes Policy, would apply to the headwaters and intermediate watershed zones, and to a large portion of the valley watershed zone.

Potential management conflicts are more zone and site specific within the Basin. The type, nature and extent of potential watershed management conflicts with park management, varies considerably in different areas of the Basin. Topographic and microclimatic variations, and subsequent differences in environmental patterns, watershed conditions, land use patterns and capabilities, and differences in resource demand patterns within the Basin, provide the basis for these different types and degrees of management conflicts. Therefore, considerably different types and intensities of management conflicts are possible in each of the three watershed zones (headwaters, intermediate, valley).

Potential conflicts between watershed management and park management are highly variable within each watershed zone. Site specific variations in environmental patterns, land use capabilities and other factors, result in some sites having a much higher potential for conflict than other sites within the same zone. For example, development of a potential reservoir site in an existing wilderness area, would result in a higher degree of conflict than development of a potential reservoir site, in an area of low environmental significance.

In order to assess potential limitations for either watershed management or park management, the strategies required to optimize both watershed and park objectives must be compared. In such a comparison, the implications of these strategies must be assessed at the general level, the zone level and the site specific level. The implications of these management strategies, while not readily apparent at the general level, become much more explicit at the zone and site specific level. By identifying zone and site specific management conflicts, it should be possible to assess the potential implications of the management guidelines required for one use, on other potential resources uses. In this chapter, the management guidelines identified in the East Slopes Policy and management guidelines implicit in related legislation, will be applied to the Basin in general terms and then specifically to each watershed zone. Limitations to watershed management in each watershed zone will be discussed, with site specific examples of potential management conflicts used to illustrate the extent of management conflicts possible within each zone.

6.2 Compatibility of Proposed Management Strategies

The maintenance of suitable watershed conditions, required to meet watershed objectives of regime improvement, water quality maintenance and erosion control, requires the application of appropriate land use guidelines. To some extent, this degree of land use control is provided by the East Slopes Policy land use guidelines. On this basis, management guidelines for watershed protection and for protection of lands for park purposes are complementary to some degree. For example, the East Slopes Policy guidelines for land use in the prime protection zone precludes most land use activities having a high potential for environmental impact (Alberta Government, 1984). As large-scale environmental impacts such as forest clear-cutting are damaging to watershed, in situations where regime improvement is emphasized, and since this also detracts from park values, prohibition of such activities would be of benefit to both resource uses.

The East Slopes Policy guidelines for the prime protection zone also prohibits uses such as mining, oil and gas exploration, commercial forestry operations, domestic grazing, industrial development and other such activities. Exclusion of these potential uses would enhance the recreational potential of the study area. Prohibiting these uses would also provide for a high level of natural resource protection, required under park conservation objectives. Prohibition of such uses should also ensure the growth of healthy vegetation and minimize erosion. This would ensure the maintenance or improvement of existing watershed conditions.

The East Slopes Policy guidelines also restrict commercial development and site intensive recreational development within most areas of the Basin. Management guidelines for the prime protection zone limit land use to dispersed recreational activities such as hiking and related backcountry activities (Alberta Government, 1984). Motorized recreational activities are not permitted in the prime protection zone and equestrian use is prohibited in the portion of the zone designated as Wilderness Areas (Alberta Government, 1984; Alberta Recreation and Parks, 1981b).

The management guidelines for the general recreation zone would limit intensive recreational use to the North Saskatchewan River Valley, where it could be argued that the potential for additional watershed damage is relatively low. The management guidelines for the small facility zone located adjacent to Abraham Lake, also limits the extent of environmental impact, by concentrating major facility development (the Odyssey resort complex) and intensive recreational use, in a relatively small area. Random, uncontrolled, and largely informal recreational use is the major impact upon watershed conditions in the upper North

Saskatchewan Basin (Pettapiece, 1971; E.R.F.C.B., 1969). Therefore, it could be argued that any formalization of existing recreational use, implied in the East Slopes Policy and in potential development of a provincial park, would be entirely complementary to watershed management objectives (Alberta Government, 1977). However, this assumption is only partially true.

6.3 The Potential For Management Conflicts

There are several major limitations to watershed management inherent in the East Slopes Policy. Although the East Slopes Policy, park management guidelines, and wilderness area management guidelines provide for a high degree of watershed protection, these guidelines may also limit active watershed management. Although the protection of existing watershed conditions is assured, the application of measures for improving upon one or more components of streamflow has a high potential for conflict with park and wilderness objectives. For example, development of artificial storage to facilitate regime improvement, would not be appropriate to park conservation objectives, as this would involve destruction of the very conditions being protected under these conservation objectives. Similarly, non-structural watershed management techniques might also conflict with conservation objectives. Vegetation manipulation programs which might be required to maintain healthy forest growth would conflict with the maintenance of natural processes, which is an essential part of wilderness management.

The potential for management conflicts is partially due to the fact that terms such as watershed protection and watershed management are seldom defined and may have very different meanings. Watershed protection implies protection of existing environmental conditions by the exclusion or regulation of land use activities deemed to have a potential to impact upon these conditions. Alternatively, watershed management may imply modification of existing environmental conditions, in order to improve upon one or more components of streamflow. This could involve the application of a wide range of structural and non-structural management techniques. The actual management techniques required in any basin, would depend upon existing watershed conditions; how adequate these conditions are in relation to on-site and downstream water demands; and the physical potential to improve upon these existing conditions. Watershed protection, as implied by the East Slopes Policy and park and wilderness management guidelines, is only one possible management technique. The actual watershed management requirements in any basin may range from passive management, as implied by watershed protection, to total modification of watershed conditions, through both structural and non-structural means.

In the East Slopes Policy, the term watershed is used in the context of watershed protection, which results in a complete failure to recognize the potential for watershed improvement through management. This deficiency has resulted in the potential for major limitations to active watershed management in the upper North Saskatchewan Basin, as well as other East Slopes watersheds.

A second major limitation to active watershed management, imposed by management of the Basin for park purposes, results from a lack of flexibility to respond to changing resource demands. The basis of conservation implied by park management is that the natural environment will be protected in perpetuity. However, watershed management objectives are developed in response to downstream and on-site water requirements. As these on-site and downstream water requirements may change considerably over time, management objectives, and the management techniques required to meet these objectives, may also change considerably through time. Therefore, watershed management objectives must be relatively flexible while park management objectives remain relatively fixed through time. These differences may result in considerable management conflicts in the medium to long-term. For example, land allocations and management practices compatible with watershed management objectives at the present time, may not be as compatible in the future, due to changing demand patterns and subsequent changes in watershed management requirements within the Basin.

These potential differences in the timing of management objectives could result in considerable resource management problems. For example, maintenance of existing regime patterns, maintenance of water quality and erosion control are appropriate watershed management objectives for the upper North Saskatchewan Basin at the present time. A management strategy to realize these objectives might include the prohibition of land uses such as commercial forestry, mining, oil and gas exploration, commercial grazing and other such uses, which have a potential to impact negatively upon these watershed conditions. Part of this management strategy might include the specific allocation of lands within the Basin to specific uses. The designation of headwater areas as wilderness areas and the allocation of all other lands within the Basin for a provincial park, might complement this watershed management strategy. Therefore, park and wilderness area management guidelines, as applied to lands within the Basin, might provide for adequate protection from development, in order to meet these watershed objectives.

However, twenty-five years later, downstream water requirements may have changed substantially. New watershed management objectives may be required in response to these new demands. Assume for the purposes of this example, that existing streamflow is no longer adequate in relation to downstream demands, with the major problem being insufficient winter flows. On this basis, changes in the seasonal distribution of flow or improvements in yield might be required. Assuming that watershed objectives are modified to ensure the maintenance of water quality, while substantially improving upon regime, a very different management strategy might be required. An appropriate management strategy for regime improvement might require additional on-stream storage, stream diversions, active snow pack management and the application of other structural and non-structural techniques.

However, the lands required for management to meet these modified watershed objectives have already been allocated in perpetuity for park and wilderness protection purposes. At this point, these lands would have already been managed for conservation and recreation objectives for an extended period of time. Therefore, it would become very difficult, if not impossible, to remove these areas from their protected status, to facilitate the building of dams and clearing of forests. The application of such measures within established parks and wilderness areas, in order to meet new water demands downstream, would be in direct conflict with the rationale behind the establishment of these areas in the first place. Decision-makers faced with such a situation, would find themselves in the difficult position of having to trade-off essentially one exclusive use, for another exclusive use. It could be assumed that a provincial park or wilderness area, being in existence for twenty-five years, would have extremely high value for both conservation and recreation, especially if wilderness and natural landscapes were becoming an increasingly scarce commodity. On the other hand, downstream water demands may have evolved to such an extent that additional water resource projects and active watershed management programs become essential. For example, additional on-stream storage, combined with vegetation and snowpack management programs, might provide the only technologically feasible means of satisfying downstream water demands.

Any environmental manipulation of the scale required by the construction of additional on-stream storage and related watershed management programs, would destroy the wilderness character of the Basin; would be in direct conflict with wilderness management philosophies of preventing the impact of man while protecting the evolution of natural environmental processes, and would also have the potential to damage recreational values. Prevention of development and exploitation, as part of the management strategy for parks and wilderness areas, would essentially mean that the modified watershed management objectives could not be fulfilled and downstream water demands could not be met.

Some degree of trade-off might be acceptable, whereby some degree of wilderness value is sacrificed to permit some degree of watershed development. However at this point, any such unplanned trade-offs would be very controversial and might not be sufficient to satisfy either watershed management or park purposes. Consequently, the fact that park and wilderness area management objectives remain relatively fixed through time, while watershed management objectives may change in response to changing demand patterns, could provide the basis for considerable resource management conflicts in the long-term.

There may also be some changes in park and wilderness area management objectives which may also affect watershed conditions. For example, in order to prevent a decline in ungulate populations which would result from maturing forest cover, some reduction in fire control might be required, so that new clearings are created. Controlled burning or cutting could also be possible, if park or wilderness management strategies were changed from protecting natural processes, to simulating natural processes through management. If such management changes were to occur in the future, the upper North Saskatchewan Basin would be a probable area of concern.

At the present time, conflicts between watershed management and other resource uses in the upper North Saskatchewan Basin are relatively minor. This is largely due to the fact that lands within the Basin are not actively managed for either watershed or park purposes, and any site specific resource uses are well dispersed. However, the possibility of more active management of the Basin, for both watershed and park purposes in the future, could lead to potential management conflicts. The establishment of a major provincial park in the Basin would ensure active management of lands within the Basin for park purposes. However, changes in both on-site and downstream water demand patterns could require additional on-stream storage capacity at some point in the future. Active watershed management programs might also be required to supplement such developments. Due to the potential for long-term resource management conflicts, it is essential to have a comprehensive understanding of these problems. Through an understanding of the potential conflicts at an early stage, these factors can be given consideration in any long-range, integrated resource plans developed for the Basin. This may help to ensure greater management flexibility and minimize some of these potential management conflicts in the future.

A logical "first step" in such a process would be to analyze the existing management guidelines contained in the East Slopes Policy and related legislation and to identify and evaluate potential watershed management strategies. By identifying these requirements, it should also be possible to identify any potential limitations to the application of watershed management strategies within the Basin, under these existing guidelines. It would then be possible to project these trends into the future and to estimate the potential for long-term management conflicts, under different sets of conditions.

6.4 General Limitations to Watershed Management

There are several limitations to watershed management contained in both the East Slopes Policy and in the existing legislation governing wilderness areas, natural areas, and ecological reserves. These limitations would apply generally to all three watershed zones (headwaters, intermediate, valley) in the upper North Saskatchewan Basin. It has also been assumed by the author that similar limitations would also apply to any lands within the Basin, designated as a provincial park.

The East Slopes Policy guidelines outline specific management strategies to be applied in each of the East Slopes zones. These strategies could have major implications for watershed management at the present time. The guidelines for the prime protection zone specify that management programs such as fire control and sanitation cutting would be provided only where a proven hazard to merchantable timber exists outside the zone (Alberta Government, 1977). However, this strategy is contrary to actual watershed management requirements. In order to meet the defined objectives of regime maintenance or improvement, water quality maintenance, and erosion control, a high level of fire protection is required. The importance of this degree of fire detection/suppression capability was identified as being of critical importance to watershed protection by the Eastern Rockies Conservation Board and by several researchers (Laycock, 1973, 1957a; Pettapiece, 1971; E.R.F.C.B., 1969). The potential environmental implications of forest fires on watershed conditions have been discussed in detail in chapter 4. This difference between watershed management requirements and present management guidelines could be a major source of conflict, resulting in a high potential for watershed damage and subsequent deterioration in streamflow regime and water quality.

A similar problem exists with the control of insect infestations and tree diseases within this zone. The East Slopes Policy guidelines indicate that control or eradication measures would only be undertaken where a proven hazard to timber outside of the prime protection zone exists. Although "proof" of infestation or disease is easily established, there may be some reluctance on the part of decision makers to accept this evidence as being a significant hazard, in relation to timber outside of the zone. There is also little recognition of the importance of timber within the zone. Since approximately twenty percent of the entire East Slopes Region and ninety percent of the study area is zoned as prime protection, the potential impact of any infestations within the zone could be considerable, without creating a threat to merchantable timber in other zones (Alberta Government, 1977). This is especially important when one considers that the most important watershed areas are within the prime protection zone. Since healthy, mature forests are required for regime maintenance/improvement, water quality maintenance and erosion control, the application of a management strategy which prevents the use of measures to ensure that these required conditions are maintained, is not acceptable. Therefore, the present management strategy, as defined by the East Slopes Policy, does not provide the degree of forest protection required to maintain acceptable watershed conditions. Although this management strategy is appropriate to meeting park objectives of allowing natural processes to continue unimpeded by man, such measures have a negative impact from a watershed management standpoint.

This management strategy could also conceivably prevent the application of watershed rehabilitation or improvement programs, which could be required to repair damaged areas within the Basin (e.g. seeding disturbed areas with grasses). These measures could be required locally to control erosion or otherwise improve watershed conditions. However, such modifications to the environment and interference with natural processes would not be very compatible with the overall management strategy for the prime protection zone. Failure to rehabilitate any areas of the Basin which become badly damaged due to land use activity, or through negligence, could result in an overall deterioration in watershed conditions. This deterioration could lead to substantial increases in erosion and subsequent increases in stream sedimentation. Therefore, failure to apply rehabilitation measures where required by watershed conditions, would also not be appropriate to the watershed management objectives defined for the Basin.

Specific management guidelines for the general recreation zone are not well defined. It is assumed that any rehabilitation measures would be oriented toward site improvement for recreational purposes, as opposed to watershed improvement. The overall management emphasis within this zone is to provide for a wide range of dispersed and concentrated outdoor recreational activities, while maintaining the natural environment. This management strategy may provide for some degree of watershed improvement, but this would be limited to more indirect benefits. For example, fire protection measures and the control of other natural forest enemies might be possible within this zone. However, these measures would be applied in order to maintain recreational carrying capacity, rather than to maintain watershed conditions. Similarly, formalization of recreational use and development of facilities, which would accompany the establishment of any park in the North Saskatchewan River Valley, might limit some watershed damage. However, any indirect benefits to watershed management could be offset by the impacts of increased recreational use. The Eastern Rockies Forest Conservation Board identified the strict control of recreational use and related activities within the upper North Saskatchewan Basin as being an important prerequisite to the maintenance of good watershed conditions (E.R.F.C.B., 1969).

The potential for increased recreational use, both within the North Saskatchewan Valley and in other areas of the Basin, is considerable. Use could increase significantly, if access were improved to backcountry areas or a provincial park was established. The potential for increased erosion caused by facility development and site deterioration caused by increases in use, especially in backcountry areas, may increase stream sedimentation. Greater numbers of visitors to backcountry areas of the Basin could also increase the frequency of forest fires (Connaughton, 1972; Hoffman, 1971). However, it may be possible to balance this increased fire potential, by public education and by the presence of hikers in the area, to report or assist in the suppression of fires. This increased fire frequency, combined with a relatively low emphasis upon fire suppression could have serious consequences. The potential for stream pollution, related to the problems of sewage disposal, could also be increased by greater recreational use. Research in other areas, most notably in the U.S., has indicated this to be a major problem in watersheds with heavy recreational use (Pollution Control Council, 1961).

In summary, the potential for increased recreational use within the Basin, which is encouraged by the East Slopes Policy zoning and land management guidelines, may have a considerable impact upon existing watershed conditions. Management strategies associated with increased recreational use, could possibly subordinate the importance of these watershed conditions and might further limit active management of the Basin for watershed purposes.

A major deficiency in the East Slopes Policy is a failure to consider watershed management requirements within the Basin, in relation to the operational requirements of the Bighorn Dam. Reservoir sedimentation can become a major problem in basins where watershed conditions have deteriorated. The land management strategy implied by the East Slopes Policy could result in deterioration of watershed conditions through a failure to provide adequate control over forest fires, insect infestations and other natural forest enemies and through the environmental impact of recreation and other uses. The combined effects of vegetation removal and site disturbance associated with recreation, could result in increased erosion and subsequent increases in stream sediment loads. Since all streams within the Basin drain into the North Saskatchewan River and eventually into Abraham Lake, sedimentation could become a serious problem in the long-term. The potential impacts of reservoir sedimentation on water quality and fisheries, as well as on the operation of dams for hydroelectric power production, are well documented in the literature (Hagen and Roberts, 1973; Richardson and McEvoy, 1973). The existence of relatively heavy sediment loads in the North Saskatchewan River at Abraham Lake, has also been noted (Pettapiece, 1971). However, the sources of sediment have not been adequately documented and it is not known how much cover modification would be required to reduce sedimentation. Therefore, due to the potential for increased sedimentation and the possible implications for both water quality and power production, application of a land management strategy which could increase this problem over time, does not seem reasonable. Since the long-term implications of the management guidelines for the prime protection zone and the management guidelines required for the maintenance of ideal watershed conditions appear to be very different, future resource management conflicts are highly probable.

The Wilderness Areas, Ecological Reserves and Natural Areas Act also limits the application of watershed management programs within the Basin. The provisions of this Act would apply to the two existing wilderness areas and to the Kootenay Plains. In addition, this Act would apply to any portions of the Basin designated as controlled buffer zones. The Cline and Whiterabbit Valleys are potential areas for this designation. The Wilderness Areas, Ecological Reserves and Natural Areas Act could ultimately apply to as much as 70% of the Basin. All such lands are currently zoned as 'prime protection' under the East Slopes Policy and are located within the headwaters and intermediate watershed zones. Under the provisions of the Wilderness Areas, Ecological Reserves and Natural Areas Act, no licence, interim licence or permit shall be issued under the Water Resources Act, for any diversion, undertaking or works within any wilderness area, ecological reserve, natural area or controlled buffer zone (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). This provision would effectively preclude any further water resource developments within the Basin. Although additional storage is not presently required, downstream and on-site water demands may change in the future and additional storage might be required. This Act ensures the protection of wilderness values within the Basin, but it also limits any future options for developing additional water resource projects, to meet changing water demands. This may not be important in the short to medium term, but there could be major implications in the long-term, should demand patterns change sufficiently. Failure to recognize this possibility at an early stage in the planning process, could result in considerable resource conflicts in the future, as described previously in this chapter.

The Wilderness Areas, Ecological Reserves and Natural Areas Act also limits the application of supplementary watershed management techniques within the Basin. If any potential watershed management programs were to be applied within the Basin, these would be most effective within the headwaters and intermediate watershed zones, which produce most of the runoff. However, the majority of these lands are also located in the White Goat and Siffleur Wilderness Areas and in the areas which could become controlled buffer zones. All lands in the headwaters and intermediate watershed zones are also within the East Slopes prime protection zone. This land status effectively precludes the application of any watershed improvement or rehabilitation measures and may also fail to provide the necessary degree of environmental protection required for watershed purposes. The management strategy required to meet wilderness management objectives, as defined by the Wilderness Areas, Ecological Reserves and Natural Areas Act, would involve preserving the environmental integrity of these areas by allowing natural processes to continue unimpeded by man. However, natural processes may be very detrimental to watershed conditions. This would imply minimal control of forest fires and insect infestations. Since these natural forest enemies can effectively remove or undermine the healthy, mature vegetation, required to maintain favourable regime and water quality, a management strategy which emphasizes natural processes, is not appropriate from a watershed management perspective. Similarly, the application of measures such as selective thinning, to maintain stand age diversity or snow pack management to improve regime, would not be possible under this defined wilderness management strategy.

The areas of the Basin most appropriate to meeting wilderness management objectives, are also the same lands which are most appropriate for management to fulfill watershed objectives. In many cases, the management strategy required to meet wilderness objectives (i.e. the protection of wilderness from the impact of man) and the potential management strategies for watershed improvement (i.e. vegetation manipulation) tend to be mutually exclusive. Therefore, the potential for future land management conflicts could be relatively high.

Designation of lands within the North Saskatchewan Valley as a provincial park may also limit the application of watershed management programs. Although these lands are not as important as the higher elevation areas in terms of total runoff, and may not be as responsive to management, rehabilitation measures or local watershed improvements might be required, where areas have deteriorated through use. The extent of any potential watershed improvement or rehabilitation programs in this area, could be limited because of the management emphasis placed upon resource protection and outdoor recreation objectives. It would be logical to assume that any potential watershed improvement or rehabilitation measures would have to be compatible with park management objectives in order to be acceptable. On this basis, watershed management objectives would tend to be subordinate to park management objectives in any area designated as a provincial park. However, there may be some opportunities for complementary management for both objectives, in some situations.

In general, the designation of lands as wilderness areas, ecological reserves, provincial parks or controlled buffer zones might limit the degree to which these lands could be managed for optimum watershed purposes. Although the allocation of lands to "park" uses would not totally preclude watershed management objectives, any watershed management strategy with the potential to conflict with park management objectives might be subordinated in importance. However, where optimum environmental conditions for watershed (depending upon objectives) are similar to the optimum conditions appropriate to park objectives, some degree of compatible management for both objectives could be possible. In cases where the required watershed management techniques conflict with recreational use, or with the principles of conservation used by a parks agency, complementary management might not be appropriate. For example, the application of watershed management techniques which involve environmental modification might not be acceptable within any protected area. This would effectively limit vegetation management programs, snow pack management, construction of structures for impoundment or diversion of water, or other such measures, which might be applied in order to modify runoff patterns within the Basin. Specific examples of potential conflicts between management of the Basin for watershed and for park purposes are evident in each watershed zone. The nature and extent of these potential conflicts may be described by comparing the requirements of each management strategy, when applied to a specific watershed zone.

6.5 Zone Specific Management Conflicts

6.5.1 Headwaters Zone

The headwaters zone includes all areas of the upper North Saskatchewan Basin above 2000 m in elevation. This includes the majority of lands within the White Goat and Siffleur Wilderness Areas, and high elevation areas within the proposed provincial park, such as Mt. Cline, Sentinel Mountain, Elliot Peak, Lioness Peak and the White Goat Peaks. All lands within the headwaters watershed zone are located within the East Slopes Policy prime protection zone and are subject to the zoning and management guidelines developed for that zone. The rugged terrain and difficult access limit land use within the headwaters zone. This absence of land use has contributed to the evolution of favourable watershed conditions, important for water yield. High annual precipitation and cool temperatures result in a high snow accumulation and relatively slow melt rate. These factors combined with the extensive areas of exposed bedrock and minimal vegetation growth result in negligible evapotranspiration and storage losses. Consequently, a high water yield is produced within this zone.

The exposed bedrock slopes characteristic of the headwaters zone, are highly resistant to land use impacts. Surface disturbances, associated with mining activity, would be the major threat to lands within this zone. However, the absence of recoverable coal or minimal deposits, combined with the prohibition of such activities under both the East Slopes Policy guidelines for the prime protection zone and the wilderness areas legislation, would prevent any such impacts.

Increased recreational use would have the greatest potential impact on watershed conditions. Present recreational use is limited to dispersed backcountry activities such as hiking. The difficult terrain conditions and poor access currently limit the extent of this use. However, with improved access, the level of backcountry use would most certainly increase.

The exposed bedrock areas are highly resistant to the impacts of recreational use. However, the lower margins of the headwaters zone, which consist of thin, poorly consolidated soils, with fragile, stunted alpine vegetation, are highly susceptible to such impacts and could be damaged through increased recreational use. This damage may indirectly affect watershed conditions within the zone. The stunted alpine vegetation catches snow and helps to hold it in place, which causes drifting to occur and minimizes the amount of snow which is blown off. Consequently, the presence of this vegetation is important to the maintenance of snow accumulations within the zone. Loss of this vegetation through recreational use, could possibly result in some loss of snow cover, due to blow off and increased sublimation. This could contribute to a lower net accumulation of snow and some small reduction in spring runoff. Therefore, the direct impacts of recreational use could indirectly affect runoff patterns within the headwaters zone. However, this potential problem could be reduced by regulating the extent of recreational use within portions of this zone. This might be partially accomplished by formalizing backcountry use and applying measures to protect alpine vegetation.

There is a site suitable for major downhill ski facility development,in the Sentinel Mountain - Elliot Peaks area. Although the policy guidelines for the prime protection zone make allowances for ski developments on the grounds that no alternative, suitable terrain conditions exist, such developments may have a major impact on watershed conditions. The potential development in the study area would impact both the headwaters and intermediate watershed zones. Since this site lies directly above a tributary stream of the Cline River, development could result in soil erosion and subsequent stream sedimentation, especially during the construction phase.

Similarly, there would be a high potential for increased erosion and sedimentation associated with the construction of road and utility access to the site, through the Cline Valley. The potential erosion and stream sedimentation problem associated with the construction of roads and ski hills in mountain watersheds, are well documented in the literature (Satterlund, 1972; Hewlett and Nutter, 1969; Croft and Bailey, 1964; Newhall and Smith, 1964). Although the actual extent of these impacts is difficult to predict at this time, special measures might be applied to minimize erosion problems. For example, restricting all construction activity to the late summer and fall and the application of strict site rehabilitaion measures during construction, may reduce potential erosion and sedimentation problems. The location of roads and site development away from streams might also reduce erosion. For example, leaving a 200 m buffer zone adjacent to streams, use of drainage structures, rehabilitation of ditches during construction, and other special measures, could be effective in reducing the impact of development on watershed conditions. Although the application of such measures would result in higher construction costs, watershed impacts and potential management conflicts might be greatly reduced. In addition, this type of development and related impacts would be very site specific within the zone and with proper guidelines, downstream impacts could be effectively controlled.

The East Slopes Policy and related legislation provides for a high degree of environmental protection, while ensuring limited recreational use. The limitation of such use is appropriate to the maintenance of watershed conditions within the headwaters zone. Some secondary uses could be permitted in this zone, with minimal watershed impacts, (e.g. mining or resort development). However, these and other uses would be precluded by resource and terrain limitations. Some secondary uses, although not detrimental in the headwaters zone, would cause considerable damage in other zones, by the construction of access roads and utility corridors, through these zones.

The potential for watershed management conflicts with increased levels of recreational use is relatively low, providing that appropriate management guidelines are applied to minimize environmental impact. The high level of environmental protection implied in the zoning guidelines for the prime protection zone and in the wilderness areas legislation may also limit the degree to which the headwaters zone may be actively managed for watershed improvement. Although these high elevation, exposed bedrock areas are not appropriate for vegetation management programs, some potential may exist in the future for snow pack management to improve upon regime patterns.

The potential benefits of snow pack management within the upper North Saskatchewan Basin, or other East Slopes basins is unknown, due to a lack of research to date. However, extensive research and operational snow pack management programs in Colorado and Wyoming have produced promising results (Martinelli, 1965; Berndt, 1964; Lull and Orr, 1950). The application of such measures would involve either terrain modifications or the construction of snow fences to trap the snow. This type of environmental modification may not be appropriate to the maintenance or protection of natural conditions.

For example, the application of snow pack management programs would not be appropriate under the East Slopes management guidelines, which seem to emphasize a low level of management for resource protection or improvement. The application of snow pack management programs would not be possible in either the White Goat or Siffleur Wilderness, because the defined management objectives for wilderness areas, is to preserve the environmental integrity of these areas, by allowing natural processes to occur unimpeded by man (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). Construction of snow fences, terrain modifications or the application of materials to the snow cover to control melt, would be in direct conflict with this stated objective. Since many of the highest snowfall areas within the Basin are located within the wilderness areas, management conflicts could occur, if snow pack management was required to improve upon regime or water yields within the Basin, at some point in the future.

In summary, the management emphasis upon resource protection and outdoor recreation within the headwaters zone may be appropriate to the maintenance of acceptable watershed conditions. Potential construction of a ski area and related access routes could cause significant local watershed impacts, but these may be controlled by the application of appropriate measures during construction. The East Slopes Policy and wilderness areas legislation limits active watershed management. However, this should not present any problems in the short-term. The potential for snow pack management in the East Slopes is relatively unknown. If snow pack management is proposed in the future, it would not be possible under existing policies and legislation. Since the headwaters zone is important in terms of water yield and there is little potential for reduction in water yields under the current management strategy, watershed management-park management conflicts should be relatively low. If downstream and/or in-basin water demands change through time to the point where it becomes necessary to improve upon natural watershed conditions (e.g. snow pack management), the potential for management conflicts could become considerably greater.

6.5.2 Intermediate Zone

The intermediate zone corresponds to the middle and lower slope areas and includes all lands between 1525 and 2130 m in elevation. The intermediate zone is located entirely within the prime protection zone, identified in the East Slopes Policy. This zone includes the lower slopes of the White Goat and Siffleur Wilderness Areas, the major tributary valleys within the Basin, and the upper slopes of the North Saskatchewan River Valley.

The mature forest stands which dominate the intermediate zone slopes, provide a sharp contrast to the exposed bedrock and stunted alpine vegetation, characteristic of the headwaters zone. Because of these different environmental characteristics, the intermediate zone has a different watershed function than the headwaters zone and also has different watershed management requirements. Consequently, the type, nature and extent of potential watershed management conflicts are considerably different within this zone. There are three major areas of potential conflict within the intermediate zone; 1) limitations placed upon watershed management by the East Slopes Policy and applicable legislation, 2) direct impacts of recreational use upon watershed conditions, and 3) potential limitations to active watershed management on lands managed for park purposes.

The existence of "good watershed conditions" within the intermediate zone is largely due to the absence of any intensive land use activity during the past and very limited use at the present time. In order to ensure the maintenance of these watershed conditions, land uses having a high potential for environmental impact must be either prohibited or restricted. The East Slopes Policy guidelines for the prime protection zone provide for a high degree of land use control. Mining, oil and gas exploration, industrial development, grazing, and commercial forestry operations are excluded under these guidelines (Alberta Government, 1984). These land use controls are appropriate to both watershed management and park management objectives.

The maintenance of good watershed conditions also requires the protection of vegetation from fire and other natural forest enemies, in order to maintain mature, healthy forest stands. An appropriate level of fire protection would require early detection and suppression of all fires within this zone and within the Basin in general, in order to prevent extensive destruction of vegetation and related impacts on the watershed.

Natural forest enemies such as mountain pine beetle, spruce budworm or other such infestations, as well as tree diseases, must also be controlled to maintain good forest cover. This type of control would generally involve the application of chemical treatments, selective thinning, sanitation cutting or other such measures. In overmature stands, such as those found in many areas of the upper North Saskatchewan Basin, watershed rehabilitation or improvement programs may also be desirable, in order to improve existing stand conditions. These potential stand improvement measures might include vegetation manipulation, such as controlled forest cutting, to enhance stand age and species composition and controlled burns to simulate natural forest succession. However, it would be imperative that no surface disturbance occur, in order to prevent accelerated erosion and subsequent stream sedimentation. These and other vegetation management techniques might be successfully employed in the future to maintain or improve upon natural watershed conditions, to ensure favourable regime and water quality.

However, the East Slopes Policy guidelines for the prime protection zone and the Wilderness Areas, Ecological Reserves and Natural Areas Act, which applies to the White Goat and Siffleur Wilderness Areas, limit the degree of fire protection to be provided and also precludes the application of any chemical treatments or vegetation management programs. The management strategy for the prime protection zone, emphasizes the maintenance of natural processes (Alberta Government, 1977). Although the maintenance of natural processes is appropriate to park and wilderness management objectives, especially in reference to the maintenance of wilderness values, such a management strategy conflicts with watershed management requirements. According to the East Slopes Policy guidelines, fire control and sanitation cutting would be permitted only where there is a proven hazard to commercial timber stands outside of the prime protection zone (Alberta Government, 1984). The application of chemical treatments to control insect infestations, or the application of vegetation management programs to simulate natural forest succession, would also be prevented under these guidelines. (Alberta Government, 1984). The wilderness areas legislation also prevents the application of these measures. Vegetation management, such as sanitation cutting, application of chemicals, and other such management techniques would hardly be considered as measures to preserve the environmental integrity of these areas by allowing natural processes to continue unimpeded by man (Wilderness Areas, Ecological Reserves and Natural Areas Act, 1981). Therefore, the vegetation management strategy for watershed and the vegetation management strategy for wilderness, appear to be mutually exclusive. This could result in major management conflicts in the future, if active vegetation management programs become necessary in order to maintain or improve upon existing watershed conditions.

Similarly, these limitations would also prevent the application of vegetation management programs for snow pack modification. Assuming that snow pack management is feasible in the headwaters zone, some potential might also exist for selective forest clearing to trap the snow at lower elevations, within the intermediate zone. However, the application of such measures in the intermediate zone would also be in direct conflict with the wilderness areas legislation and would be incompatible with the zoning guidelines for the prime protection zone. Such measures would also conflict with recreational use, by detracting from the site aesthetics and natural qualities of the backcountry areas within the intermediate zone.

The intermediate zone would also be subject to direct impacts resulting from park development and subsequent increases in recreational use. The forested slopes within this zone are relatively stable and have a moderate capacity to sustain recreational use. The exposed slopes which make up approximately 20% of the intermediate zone have a much lower capacity to sustain use. The East Slopes Policy guidelines indicate that use would be restricted to backcountry activities. These activities may have a considerable impact upon watershed conditions, by causing site compaction, surface disturbances and accelerated erosion. These problems are particularly serious in areas adjacent to streams, where most of the existing informal trails are located. Specific examples of site deterioration within this zone include the trail to Pinto Lake and the Landslide Lake area, which currently experience heavy use.

The development of access roads within the zone could also increase the use of some remote backcountry areas. Ideally, such roads would be limited to a ski area access road, (assuming the Sentinel Mountain-Elliot Peaks site is developed) and short access roads, to specific backcountry staging areas. Development of access roads and trails may be accomplished with minimal impact on the watershed, as was outlined in the discussion of the ski area in section 6.5.1 (Headwaters Zone) of this chapter.

Construction of roads and trails would greatly improve access to the intermediate and headwaters zones. Increased recreational use could increase the frequency of fires in remote portions of the Basin, especially when increased use is combined with a low emphasis on fire protection.

The potential increase in the number of fires and the related erosion and stream sedimenation hazards could result in deterioration of existing watershed conditions. Although a high level of fire protection may not be appropriate to the encouragement of natural processes, it is nonetheless a major requirement of watershed management. Therefore, the direct and indirect effects of increased recreational use may have a considerable impact upon watershed conditions within the intermediate zone. However, it may be possible to reduce the extent of these potential impacts, through the careful planning of trail locations and routes. The use of special construction techniques aimed at reducing erosion, control of backcountry use and emphasis of fire protection could also be beneficial.

The construction of additional on-stream storage, to supplement the storage capacity of Abraham Lake, would be the most serious potential conflict in the intermediate zone. The three potential damsites identified in the Cline Basin at Coral Creek, Cataract Creek and on the Cline River, are not required at the present time (Alberta Department of Agriculture, 1964). However, changes in downstream demand patterns could mean that additional water or considerable regime improvements could be required, especially during the winter low-flow months. One or more of these damsites might have to be developed, if water demands exceed the storage capacity of Abraham Lake. Although additional storage may be useful to met some watershed needs, the construction problems, including associated watershed damage, combined with the impacts on other uses, might result in high costs in relation to overall benefits.

It is not likely that any lands east of the Cline River would be included within any future provincial park. However, the proximity of these lands to the White Goat Wilderness would make the Cline drainage a likely candidate for designation as a controlled buffer zone, under the Wilderness Areas, Ecological Reserves and Natural Areas Act (1981). Under the provisions of this Act, as discussed in chapter 5, no damsites could be constructed in any controlled buffer zone. This would significantly reduce watershed management options, should additional water supplies or additional regime improvement be required in the long-term, and development of these sites is appropriate.

Perhaps the logical alternative would be to delete the potential damsite(s) from buffer zone status to expedite construction, if additional storage should be required in the future.

However, these damsites are located in an area having some significant resource features. The Cline River and related tributaries have a unique canyon complex, with three canyons having a wide range of geological features found within a localized area. Several small waterfalls are also present within the Cline Sub-basin. Coral Creek Canyon also contains some 'Hoodoos' features near the potential damsite. Development of any one of the potential damsites would destroy some of these significant resource features and would also destroy the wilderness characteristics of the area. Recreational use might also be affected, due to the deterioration of site aesthetics caused by the dam site. Since this area was once part of the White Goat Wilderness Area, opposition to development would also be expected.

On this basis, development of additional storage in the Cline sub-basin would conflict with both wilderness management and outdoor recreation objectives. Therefore, there could be a high potential for conflict between watershed management and wilderness management objectives within the intermediate zone, should it become necessary to develop one or more of these sites.

In conclusion, there are three potential management conflicts specific to the intermediate zone. Potential conflicts relating to forest stand management for wilderness purposes, as opposed to watershed purposes may be considerable. Some compromises may be possible, without overly subordinating either set of objectives. Increased recreational use of backcountry areas within the zone may create undesirable impacts upon watershed conditions. When this use is combined with a lack of fire protection, central to wilderness objectives, there may be a considerable potential for watershed damage. These potential conflicts may be partially controlled, through good planning and the application of special trail construction measures, combined with use controls. Some degree of compromise might also be possible relative to fire protection. While protection from fire is essential from a watershed management standpoint, it may not be as important a compromise from a wilderness management perspective. Therefore, it may be possible to provide for a high degree of fire protection without unduly compromising wilderness management objectives.

The possibility of additional storage within this zone creates some potential for future management conflicts. The actual degree of conflict would depend on whether this need materializes in the future and on the relative importance of wilderness and watershed values at that point in time. However, planning in the short to medium term should include consideration of the potential for such future developments and related use conflicts. This could involve 'building in' the flexibility for such developments to take place, if environmentally and economically acceptable, or making a firm decision to protect the Cline Valley and its tributary valleys from any future developments. In any case, a detailed examination of the issues and all possible alternatives is of major importance. The potential management conflicts within the intermediate zone could perhaps best be described as moderate at the present time, recognizing that serious conflicts could occur in the future. The potential for management conflicts is much greater in the intermediate zone than in the headwaters zone. The relative ease of access, the existence of fewer topographical constraints to development and greater land use pressures are factors largely responsible for this increased potential for management conflicts. Similarly, the forested slopes are much more susceptible to impact than the rugged bedrock slopes of the headwaters zone. Conditions in the intermediate zone have a major impact upon total runoff characteristics within the Basin. Since all water rising within the headwaters zone passes through the intermediate zone, land use impacts may have a considerable effect on the quantity, quality and timing of runoff. Therefore, it is essential that potential management conflicts be resolved, in order to ensure the maintenance of acceptable watershed conditions within this zone and within the Basin in general.

6.5.3 Valley Zone

The valley zone corresponds to the middle and lower elevations of the North Saskatchewan River Valley and includes the extreme lower reaches of the major tributary streams such as the Cline River, Siffleur River, and Whiterabbit Creek . This generally includes all lands within the Basin, below 1525 m in elevation. Three different "East Slopes" zones are represented within the valley watershed zone; prime protection, general recreation, and facility. Therefore, three different sets of management guidelines currently apply to the valley zone. The combination of these different management guidelines, the existence of land use pressures, and a relatively fragile environment, all within a small land area, could lead to complex resource management problems and a high potential for watershed damage.

The middle slopes and Kootenay Plains area of the North Saskatchewan River Valley form part of the prime protection zone and are therefore subject to the same management guidelines as lands within the headwaters and intermediate watershed zones. Terrain conditions in the middle slopes area are similar to those of the lower margins of the intermediate zone. However, exposed grass slopes and lower density forest stands are more prevalent. The Kootenay Plains are "a unique and fragile, semi-arid grassland environment" (Wallis and Wershler, 1981). The dry microclimate and poorly consolidated, fine-textured soils within these two areas, are much more susceptible to the impacts of recreational use than soils under the coniferous forests of the intermediate zone (Pettapiece, 1971). The potential for soil erosion would also be higher, with increased recreational use. The Kootenay Plains area is particularly susceptible to such impacts and the erosion potential could be described as extreme, within certain localized sites. Although land use in this portion of the prime protection zone would also be oriented towards dispersed, backcountry recreation, use of these areas could be heavy, due to ease of access, concentration of facility development in the adjacent general recreation zone, and close proximity to the David Thompson Highway.

Protection of these fragile grassland areas would be essential to meeting the watershed management objectives defined in chapter 4. Although special trail construction methods and formalization of recreational use might be of some benefit, high potential use levels might still exceed the low, albeit improved, recreational carrying capacity, in these environmentally sensitive areas. This could increase soil erosion and thereby increase stream sedimentation. This level of deterioration in watershed conditions would be unacceptable, given the need to maintain water quality and to minimize the effect of sedimentation on dam operations.

Restricting recreational use might be an appropriate method of reducing the soil erosion potential from a watershed management perspective, but such a strategy would reduce the recreation benefits derived from these areas. Therefore, some potential exists for conflicts between recreational use and watershed management, due to the different management requirements associated with each of these uses.

The East Slopes Policy guidelines applied to the prime protection zone may also conflict with watershed management requirements in this portion of the valley zone. The dry climate and constant winds within the North Saskatchewan Valley often create a high fire hazard during the summer months. The grassland areas are highly susceptible to fire damage. Since this grass cover protects the soil, fire would result in extensive erosion, causing considerable deterioration in watershed conditions and subsequent deterioration in water quality. Therefore, a high level of fire protection is required to protect this fragile grassland environment, in order to maintain good watershed conditions. However, the East Slopes Policy guidelines indicate that fire protection would only be appropriate where a hazard exists to timber outside of the prime protection zone (Alberta Government, 1984). These guidelines are clearly not appropriate to the maintenance of acceptable watershed conditions in the Kootenay Plains and other areas of the valley zone.

There are several sites within the valley zone, which have deteriorated with existing use, or which were not properly rehabilitated following construction of the Bighorn Dam. There are also several sites, especially on the alluvial fan slopes, which have a high potential for erosion. Erosion of these deteriorated sites and any potential slumpage directly into Abraham Lake or into the North Saskatchewan River, could result in sedimentation problems. Reclamation measures might be beneficial in many such areas. However the application of these measures might be restricted in the middle slopes area, by the East Slopes Policy guidelines, and might be prohibited in the Kootenay Plains, by existing legislation. Slope stabilization, using concrete or other materials, or extensive seeding and fertilization would not be compatible with the management objectives for natural sreas, which are essentially managed to preserve existing environmental conditions in the area, while allowing natural processes to occur, unimpeded by man (Wilderness Areas, Ecological Reserves, and Natural Areas Act, 1981). Similarly, the application of such measures might be limited within other areas of the valley zone, if the rehabilitation measures detracted from site aesthetics, or were sufficient to reduce recreational use.

Management of the Kootenay Plains Natural Area is of considerable importance to watershed protection, since the North Saskatchewan River flows through this area. Material eroded from these fragile grasslands enters the river at a rapid rate and is quickly transported to Abraham Lake, where the reduction in flow velocity results in deposition (pettapiece, 1971). The relatively high rate of sedimentation is further enhanced by ongoing aeolian processes in the valley, and by the naturally heavy sediment load carried in the North Saskatchewan River, due to its glacial origins (Pettapiece, 1971; McPherson, 1970).

Protection of riparian vegetation, which stabilizes the stream banks and shorelands and creates a natural hydrologic buffer, is very important for erosion control. Some degree of protection may be provided for these riparian areas by Natural Area status, but random recreational use adjacent to the North Saskatchewan River has the potential to damage these areas as well. Where such damage has occurred, rehabilitation measures might also be precluded by the management emphasis being placed on the maintenance of natural processes.

In summary, the protection of grassland areas such as the Kootenay Plains, from both natural erosion and the impact of uncontrolled recreational use, is essential for meeting the watershed management objective of erosion control. The provision of a high degree of fire protection, the protection of both grassland and riparian vegetation, application of site reclamation measures and the control of recreation and other land uses, are potential watershed management requirements. However, this management strategy is not entirely compatible with either the existing management guidelines for natural areas or the stated management guidelines for the prime protection zone. Failure to integrate watershed requirements into this management strategy could result in more serious conflicts and greater watershed damage in these areas, especially if there is a significant increase in recreational use.

The general recreation zone component of the valley watershed zone, is allocated to more intensive recreational use than the prime protection zone. Although the management guidelines for this zone include emphasis upon maintenance of the natural environment for recreation, facility development and site intensive recreation would be concentrated in this corridor. The construction of campgrounds, staging areas to support backcountry activities, and other such developments, may have a considerable impact on existing watershed conditions. Many sites within the general recreation zone component are only slightly more resistent to impacts than the Kootenay Plains and middle slopes sites. The construction of such facilities in this area would likely increase soil erosion, as these soils are also fine-textured and poorly consolidated (Pettapiece, 1971). Many of the most desirable sites for potential development are located in close proximity to streams. Although these sites have suitable terrain and aesthetic qualities for development, soil conditions are such that these sites would have a low to moderate capability to sustain intensive use. Intensive recreational use or improper site development could result in considerable soil erosion. Development of recreational facilities in close proximity to streams might also result in stream pollution and some reduction in water quality. Improper sewage disposal and runoff from intensively developed sites such as campgrounds, could be a potential source of stream pollution (Hopkins, 1965). By locating recreational facilities away from streams, it would be possible to reduce potential sedimentation and pollution problems, while maintaining a high degree of watershed protection. Maintenance of an adequate buffer area adjacent to all streams would also protect riparian vegetation, thereby minimizing erosion, and would provide a hydrologic buffer to runoff entering the streams. Although the application of these measures may be apropriate to meeting watershed management objectives for the Basin, facility development and subsequent recreational use might be negatively affected. Some trade-offs might be required in order to minimize these potential conflicts. However, the land management strategy defined for the general recreation zone in the East Slopes Policy, is almost exclusively oriented toward recreation. Therefore, because of the heavy management emphasis placed on recreation, one would assume that watershed requirements would be subordinated in relation to recreation objectives, in any trade-off situation.

The facility zone component of the valley watershed zone, located above the Abraham Lake reservoir, at its confluence with the Cline River, is designated for very intensive, site specific recreational development. The possible construction of the Odyssey resort complex on this site, could also conflict with watershed management objectives. Problems relating to stream sedimentation and pollution might be expected at this site. Due to the scale of development and operating implications, these problems could be much greater than those anticipated in the general recreation zone. For example, a considerable volume of sewage could be generated by the resort on a year-round basis. Storm runoff from the complex would likely contain oil, chemical residues, and other pollutants, and these pollutants would wash directly into the reservoir. Considerable land disturbance would also occur during the construction phase, which could involve deposition of soil directly into the reservoir through erosion or through slope disturbance. The location of this site directly adjacent to both Abraham Lake and the Cline River, intensifies the potential for watershed damage. Although the extent of these direct impacts would be limited to the facility zone itself, indirect impacts would be more widespread and could affect water quality in downstream areas.

The development of facilities in the valley zone, could also have indirect impacts in the intermediate and headwaters watershed zones. The provision of intensive facilities in the valley zone would improve access to other areas of the Basin, as well as attract large numbers of users to the area.

The potential for watershed management conflicts within the valley zone is much greater than in either the headwaters or intermediate zone. The complexity of land use pressures in this zone, combined with the application of three different management strategies under the East Slopes Policy, to a relatively small area, is a major source of this potential conflict.

Another major problem is that the relationship between land use and runoff has not been given adequate consideration in the management guidelines for either the general recreation or facility zone. The possibility of intensive development within these zones, in close proximity to the reservoir and major streams, could result in some increases in reservoir sedimentation, with the long-term possibility of some reductions in reservoir capacity. This problem is complicated further by the fact that all runoff generated in the headwaters and intermediate zones must pass through the valley zone. Even though a high degree of watershed protection in these higher elevation zones could ensure runoff of good quality and favourable regime, the impact of land use activity in the valley zone could modify the quantity, quality, and timing of runoff significantly. Therefore, land use within the valley zone may have considerable implications for both on-site and downstream water supply. Despite the importance of the valley zone in relation to the quantity, quality, and timing of runoff, the management guidelines applied to this zone are strongly oriented to outdoor recreation and conservation objectives, which are not totally appropriate to watershed management. Therefore, it is evident that watershed management requirements in the valley zone and in the upper North Saskatchewan Basin in general, have been subordinated in relation to outdoor recreation and conservation objectives. Because of the potential differences between watershed management requirements and the management requirements of conservation and recreation objectives, there is a high potential for future management conflicts within this zone. This high potential for conflict relates back to the overall failure of policy makers to recognize the requirements of watershed management and a lack of defined watershed management objectives for the study area and for the East Slopes Region in general.

The emphasis placed on conservation and outdoor recreation objectives in the East Slopes Policy, would be further enhanced by the establishment of a provincial park within the Basin. However, the formal allocation of lands in perpetuity, for park purposes, would further subordinate watershed management objectives in relation to conservation and outdoor recreation objectives. This could place limitations upon active management of lands to meet watershed management objectives. Although the designation of lands as a provincial park would provide some indirect benefits in terms of watershed protection and the formalization of random recreational use, this single-use allocation may result in medium to long term conflicts, if water demand patterns change significantly.

Any potential developments in the valley zone must also be considered in relation to potential impacts upon lands in the adjacent zones. However, in the East Slopes Policy there is an inherent failure to recognize the environmental interrelationships which exist between the different areas of the Basin. This could result in unexpected impacts in other zones, due to development of the general recreation and facility components of the valley watershed zone. Management zones, outlined in the East Slopes Policy, are considered in isolation of each other. For example, the management guidelines for the prime protection zone emphasize a very high degree of environmental protection. However, the general recreation zone and facility zone bisect the prime protection zone and thereby reduce the environmental integrity of the unit. No consideration has apparently been given to the potential 'spillover' of impacts into the prime protection zone from the general recreation and facility zone components. For example, recreational use of the prime protection zone would occur because of improved access through the general recreation zone. Therefore, the impacts of land use are not confined within a single zone. On this basis, the provision of a high degree of watershed protection in the prime protection zone, while simultaneously encouraging development of the general recreation zone, and assuming that the two issues are totally unrelated, is a very unrealistic approach to resource management.

The potential for conflict between park management objectives and watershed management objectives is also complicated further by the existence of reservoirs within areas proposed for provincial park designation. A good example of this type of situation is the establishment of Kananaskis Provincial Park, on lands surrounding two reservoirs, Upper Kananaskis Lake and Lower Kananaskis Lake, which are managed for hydro-electric power-peaking purposes. To date, there have been some minimal conflicts between park management and water resource management activities within this area. It could also be argued that the existence of these reservoirs has enhanced the park management objectives by improving the aesthetics of the area and providing opportunities for water based recreation. However, there is a potential for conflicts in the future, should the operation of the reservoir be modified in response to changing downstream demands. For example, if drawdown were substantially increased to meet increased power peaking requirements, or if additional structures for increased flow regulation were required, there could be potential conflicts with park management activities.

The basis for potential future conflicts between park management and watershed management, stems from the fact that park management objectives are largely tied to an existing water resource management situation, based upon the assumption that the on-site situation will remain constant. However, water resource management is oriented to meeting onstream, streamside and downstream demands, which may change considerably through time. In addition, the ways of modifying regime (reduction of flood flow and augmentation of low flow), erosion and sedimentation, water quality and yield, are also varied for each of these uses. Changes in downstream demand may require changes in on-site reservoir management, such as an increase in storage, increased draw-down, alteration in the timing of drawdown, or the construction of additional storage and diversion structures. Therefore, the fact that there are potential changes in downstream demand patterns which can require modifications upstream, can produce potential conflicts between watershed management objectives and park management objectives.

Within the upper North Saskatchewan Basin, a similar situation would exist if the valley area is designated as a provincial park (i.e. a pre-existing reservoir would be partially located within the park). Approximately half of the Abraham Lake reservoir would be within the proposed park, with the other half and the Bighorn Dam itself, being located outside of the park. Proposed changes to the operation at Bighorn, could have a major impact within the study area, due to the potential for increased drawdown (Alberta Environment, 1982).

Potential changes in downstream demand patterns may also have watershed management implications within the upstream areas, such as the areas proposed for park establishment or currently designated as wilderness areas.

There are many potential management conflicts associated with the impact of reservoir operations, upon management for recreation and conservation objectives. The present level of flow regulation at the Bighorn Dam, results in a considerable drawdown in the winter months. In spring and early summer, large 'mud flat' areas detract from site aesthetics to a considerable degree. (See plates 33 and 34). Site aesthetics in the facility zone, would be particularly affected by reservoir drawdown. This might have negative impacts on the use of the Odyssey resort, should it be constructed. There is some possibility that increased regulation of flow at Bighorn would result in even greater seasonal drawdown, thus expanding the 'mud flats' area and increasing the length of time that these areas are exposed (Alberta Environment, 1982). Increased drawdown would also reduce the potential for recreational use of shoreland areas and could reduce the attractiveness of the area for recreation (Frechette, 1970). The environmental impact of increased drawdown on the Kootenay Plains and other significant areas in the valley zone is not known at present, but it is expected that some negative impacts might result. For example, a portion of the Kootenay Plains area was originally flooded, following construction of the Bighorn Dam. There could also be some disruption of stream habitat, resulting from changes in stream velocity and other variables, due to increased flow regulation. Therefore, increased regulation of flow at the Bighorn Dam for regime improvement, although important for downstream purposes, may limit the degree to which conservation and recreation objectives can be optimized. For example, the potential modification of stream ecology would not be consistent with the management philosophy of allowing natural processes to occur unimpeded by man (Wilderness Areas, Ecological Reserves, and Natural Areas Act, 1981).

Future environmental impacts associated with increased drawdown might have an even greater impact on conservation and recreation objectives. This would be especially true if a provincial park were established, as these impacts would not be acceptable within a park. Even

Plate 33: Abraham Lake at Low Supply Level - April (rock outcrop near turn-off to Bighorn Dam)

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Images en couleur

Plate 34: Abraham Lake at Full Supply Level- October (same rock outcrop, photograph taken at same site, but approximately 30 m higher).

though the Bighorn Dam and most of the Abraham Lake reservoir are located outside of potential park boundaries, some flooding of park lands could occur. Therefore, watershed management activities may also 'spillover' into other areas and create potential impacts upon other land use activity in other areas of the Basin. As a result, both the existing and future operation of the Bighorn Dam may have a considerable degree of potential conflict with park management objectives.

On the basis of these and other potential park management/watershed management conflicts, a full assessment of conflicts between management objectives and guidelines is required, based upon the possibility of different downstream demand patterns occurring in the medium to long-term. This is required to ensure that potential management conflicts can be minimized in the future. Through a process of balancing park management and watershed management objectives, greater flexibility might be achieved, with the result of greater benefits from both park management and watershed activities in the future.

6.5.4 Summary of Management Conflicts

There are major deficiencies in the East Slopes Policy, both in relation to the impacts of recreation and other land use on watershed conditions and upon the impact of conservation objectives on active watershed management. The highly single-use orientation to resource management implied in the East Slopes Policy is not appropriate to meeting watershed management objectives in the long-term, because it limits watershed management in relation to recreation and conservation objectives, even though watershed is identified as the "prime use" of the East Slopes (Alberta Government, 1977). Establishment of a major provincial park in the Basin would further orient management towards optimizing conservation and recreation objectives, possibly at the expense of watershed management objectives, assuming that the present single-use approach to park management continues. Although some allowances might be made for watershed management, the extent of trade-offs possible would be limited under such a management strategy.

6.6 The Basis of Management Conflicts

The combination of the East Slopes Policy zoning guidelines and land use controls provided for by the existing legislation governing wilderness areas, ecological reserves and provincial parks, demonstrates a strong outdoor recreation/conservation management orientation for the upper North Saskatchewan Basin. Although it is recognized in the East Slopes Policy and existing legislation that the degree of emphasis placed upon either outdoor recreation or resource preservation may vary in different areas of the Basin, very little consideration has been given to the degree of restriction imposed upon secondary land use activities. Therefore, all other land uses are either subordinated in importance or precluded from the study area.

The degree to which any secondary use might be facilitated within an outdoor recreation/resource preservation management orientation, would depend entirely upon the degree to which a secondary use would be complementary to outdoor recreation or resource preservation objectives. For example, it may acceptable to remove or manipulate vegetation to improve site aesthetics or wildlife habitat within a provincial park, but it would not be acceptable to clear-cut large areas of the park for commercial forestry purposes or to facilitate stream yield improvements. Similarly, it may be acceptable to impound a creek within the park and to divert water to supply the needs of outdoor recreation facilities. However it would not be acceptable to construct a large dam to divert water for inter-basin transfer, or to facilitate on-site production of hydro-electric power. Basically, the degree to which a given land use activity is acceptable within an established park, is largely dependent on the degree to which it conflicts with, or is complementary to, the stated park management objectives, as defined by existing legislation and by the East Slopes Policy. On this basis, construction of dams, diversion works, on-stream storage or other structures required for active water resource management, could not be constructed in any wilderness area, ecological reserve or provincial park, under the existing legislation and under the management orientation defined for the upper North Saskatchewan Basin by the East Slopes Policy.

To a great extent, the potential for resource management conflicts in the North Saskatchewan Basin and within the East Slopes Region in general, is due to the application of a highly single-use approach to management. Under this single-use approach, a primary use is defined for an area. Some secondary uses may also be permitted within this same area, providing that this secondary use(s) does not conflict with the primary use. However, in the case of the East Slopes Policy, various uses, such as watershed, recreation, and resource conservation, are not considered in sufficient detail to permit a realistic assessment of potential conflicts between these uses. This approach is further limited by the fact that 'time' is not given adequate consideration. All uses or potential uses are evaluated using present demand patterns, even though some resource demands, for example water demands, may change considerably through time, while other resource demands may be more constant through time.

Another major problem with the single-use approach is that small areas or zones are delineated and a prime use established for each zone, without giving any consideration to the impact of use in one zone, on different uses in adjacent zones. Such an approach is based on the assumption that land units are not ecologically related. This is totally invalid, as has been demonstrated by the examples of conflict used in this chapter. Poorly defined management objectives for all uses enhance the potential for resource management conflicts, because actual management requirements for each use cannot be adequately assessed unless management objectives have been defined. For example, the recreation and conservation management objectives defined for both the prime protection and general recreation zones are assumed to be entirely compatible with watershed protection. However, the impacts of recreational use and a management strategy emphasizing natural processes, are not totally appropriate for watershed protection.

A third major problem is that watershed protection has not been defined in the policy, nor is it acknowledged that there are other watershed requirements besides protection. Considerable possibilities might exist in many of the East Slopes basins for watershed improvement through active management, which may or may not involve environmental preservation. For example, watershed improvement through reforestation or through the construction of additional storage may be appropriate in some basins. However, this type of impact would be incompatible with the management objectives applied to areas such as wilderness areas, natural areas, or national or provincial parks.

The absence of defined management objectives, combined with a failure to recognize the potential impact of recreational use and the application of conservation oriented management strategies, combined with allocation of lands in perpetuity to these single uses, has been further complicated by uncoordinated planning. Each resource use within the Basin is planned independently of all the other resource uses. Water resource planning for the operation of the Bighorn Dam is not considered in relation to recreation and conservation objectives. Intensive development of the valley watershed zone is not considered in relation to potential impacts on watershed conditions or dam operations. The relationship between land use and potential impacts in other areas of the Basin or in downstream areas has not been considered.

In order to alleviate these and other planning deficiencies, a multiple-use approach to planning is recommended. Under a multiple-use approach, the implications of each use could be assessed against the implications of all other uses. Potential areas of conflict could be identified. It would then become possible to identify required trade-offs, in order to integrate one or more potential uses, with a minimum of conflict. Alternative management strategies could then be developed, each incorporating a different combination of uses or intensities of use.

Watershed management objectives, recreation objectives and conservation objectives are not always compatible, nor are these always in conflict. Detailed management information is required for these and other potential uses, in order to define management objectives and appropriate management strategies for each use. The use of detailed information within a multiple-use planning framework would permit a full assessment of the implications of one potential use upon other uses, and could result in more integrated and coordinated resource use. Decisions based on this information, would be based on a much broader range of alternatives and would also more adequately reflect resource demands over a longer period of time. Changes in resource demand patterns could also be considered in this approach. The ultimate benefit of multiple-use planning would be a much better integration of potentially conflicting uses and a better allocation of resources in relation to demand, with fewer use conflicts and lower levels of environmental impact.

7. An Integrated Multiple-Use Approach to Watershed Management

7.1 The Need for Integrated Planning

The application of a single-use approach to land use and resource management in the upper North Saskatchewan Basin and the East Slopes region in general, has resulted in a considerable potential for future use conflicts and management problems. Under this approach, lands are allocated to essentially exclusive uses, with some 'allowances' made for secondary uses. These secondary uses were always assumed to be non-conflicting and non-competetive with the 'prime' use. Therefore, it was assumed that by managing lands for a 'prime' use, other secondary uses could also be realized. In the past, this single-use approach was adequate in many East Slopes basins such as the upper North Saskatchewan, because resource demands and land use pressures on a large land base were relatively low. Under these conditions, it was possible to meet several low-scale resource demands without significant conflicts between these uses and without significant, negative environmental impacts. Demands have increased considerably in recent years. In many cases, incompatible uses have been encouraged in the same area. Complex land use and resource management problems can result from these types of use patterns. The potential for environmental deterioration could also be quite high. Therefore, as demands increase in scale and complexity, the single-use approach to management becomes less and less effective and the potential for use conflicts increases.

A continuation of the single-use approach could lead to long-term allocations of lands to specific uses, to meet relatively short-term management objectives. These long-term land allocations, such as those suggested in the East Slopes Policy zoning framework and related land use guidelines, may not be appropriate to meeting future resource demands (Alberta Government, 1977). It may be difficult to change these land allocations and management guidelines, in response to changing demands over time. Therefore, management would be very inflexible. As resource demands and use pressures increase, the allocation of lands to exclusive uses, with minor allowances for secondary, non-competetive uses, will not be possible without some degree of conflict. This could become a major problem, given the present lack of well-defined, measurable management objectives and adequate resource supply and demand information. The absence of any methodology for monitoring the effects of management strategies applied, or for measuring progress toward the attainment of management objectives, is also a major limitation to the effectiveness of the single-use approach.

Although it is clear that a series of single-use management strategies may be applied to realize different objectives in specific land units or within individual watershed zones, without these uses being mutually exclusive, some land use conflicts could occur. These potential conflicts may result in reduced benefits from the use of resources in the basin and may also result in unacceptable environmental impacts. The effectiveness of the single-use approach is limited by the complexity of resource demands and the extent of existing use. As demand for uses such as watershed, outdoor recreation, wildlife, forestry, grazing, and natural resource conservation become more complex, the ineffectiveness of the single-use approach becomes more apparent. This is especially evident in situations where two or more uses must be emphasized for the same land unit at the same time. For example, in situations involving two or more uses (e.g. watershed management for yield improvement and wilderness management emphasizing vegetation protection), the potential for conflict could be high, using the single-use management approach. This is largely due to the fact that conflicting management strategies must be applied to attain considerably different watershed conditions, in order to optimize each use. Alternatively, an exclusive use approach (pure single-use) could be applied to exclude all but the 'prime' use. Although this would reduce the potential for conflict, the available resources would not be effectively utilized, especially if the use selected was not the best use of the resource. In most cases, such an approach would result in the loss of all benefits of conjunctive use. Using an approach in which a prime use is defined and allowances made for secondary uses, is much more effective than using a 'pure' single-use approach. However, both of these single-use approaches are inferior to an integrated multiple-use approach.

In the medium to long-term (20 to 50 years), resource demands in the upper North Saskatchewan Basin and East Slopes region in general, should increase and become more complex. Therefore, the potential problems noted by the author in this thesis could occur, if the present single-use approach to management is continued in the future. On the basis of these deficiencies in the single-use approach, a comprehensive, integrated, multiple-use methodology should be developed as an alternative. This multiple-use approach must be based upon the definition of quantifiable management objectives for all uses. Watershed management plans could then be developed for individual basins, using this methodology.

The integrated, multiple-use approach to management is considerably more complex than the single-use approach. Detailed resource information is required to determine capabilities to sustain a given use or group of uses. Goals must be defined to identify acceptable uses and to establish use priorities. Objectives can be developed to specify the quantity, quality and type of uses to be emphasized, based on demand patterns and land use capabilities. The definition of objectives must emphasize a high degree of flexibility and include provision for a continuing review of perceived resource supplies and the demands upon them.

In order to complete these requirements and integrate the various types of supply, demand and capability information in a logical manner to facilitate decision-making, a formalized planning process is required. By using such a process to integrate complex resource information, many of the potential management conflicts identified by the author for the upper North Saskatchewan Basin, might be eliminated in the long-term. The objective of the author in this chapter, is to describe a simple, logical process which might be used as a basis for multiple-use planning. The various steps in this process will be outlined and the information requirements at each step will be described. A very general description will be given in this chapter, using hypothetical examples where appropriate. In chapter 8, this process will be applied to resolve hypothetical management conflicts in the upper North Saskatchewan Basin, by balancing the objectives defined for watershed management and park management, in chapter 4 and 5. Alternative management strategies or 'alternative futures' for the upper North

Saskatchewan Basin will also be outlined in chapter 8. The model described in this chapter and applied in chapter 8, has been simplified to show patterns and outline a process, with as little complexity as possible. Therefore it must be stressed that this is a hypothetical model. The objectives, standards, measures, and alternatives described are examples only and do not necessarily reflect the physical capabilities of the upper North Saskatchewan Basin or political, economic, social, or technical realities.

7.2 The Integrated Planning Approach

In order to develop multiple-use management strategies capable of meeting a wide range of potentially conflicting resource demands, a logical, comprehensive planning process is recommended. Several researchers have developed comprehensive multiple-use processes and have applied these to actual resource management and land use problems (Holling, 1981, 1972; Henwood and Coop, 1973; Lukern and Langlois, 1973; McCloskey, 1973; Hewlett and Douglas, 1968). Most of these processes were oriented toward a specific problem (e.g. a spruce budworm infestation or on-site environmental impacts associated with a new damsite) and were not easily applicable to very complex, large-scale situations, such as land use and resource management conflicts in a large basin. Therefore, a relatively simple, highly generalized planning process developed by Parry (1983), was modified by the author and used as a basis for developing the multiple-use process described in this thesis. The process outlined in this chapter consists of eight specific steps; 1) Goals, 2) Objectives, 3) Measures, 4) Standards, 5) Alternatives, 6) Plan Selection/Implementation, 7) Monitoring and 8) Evaluation. The relationship between these stages is shown in Figure 10.

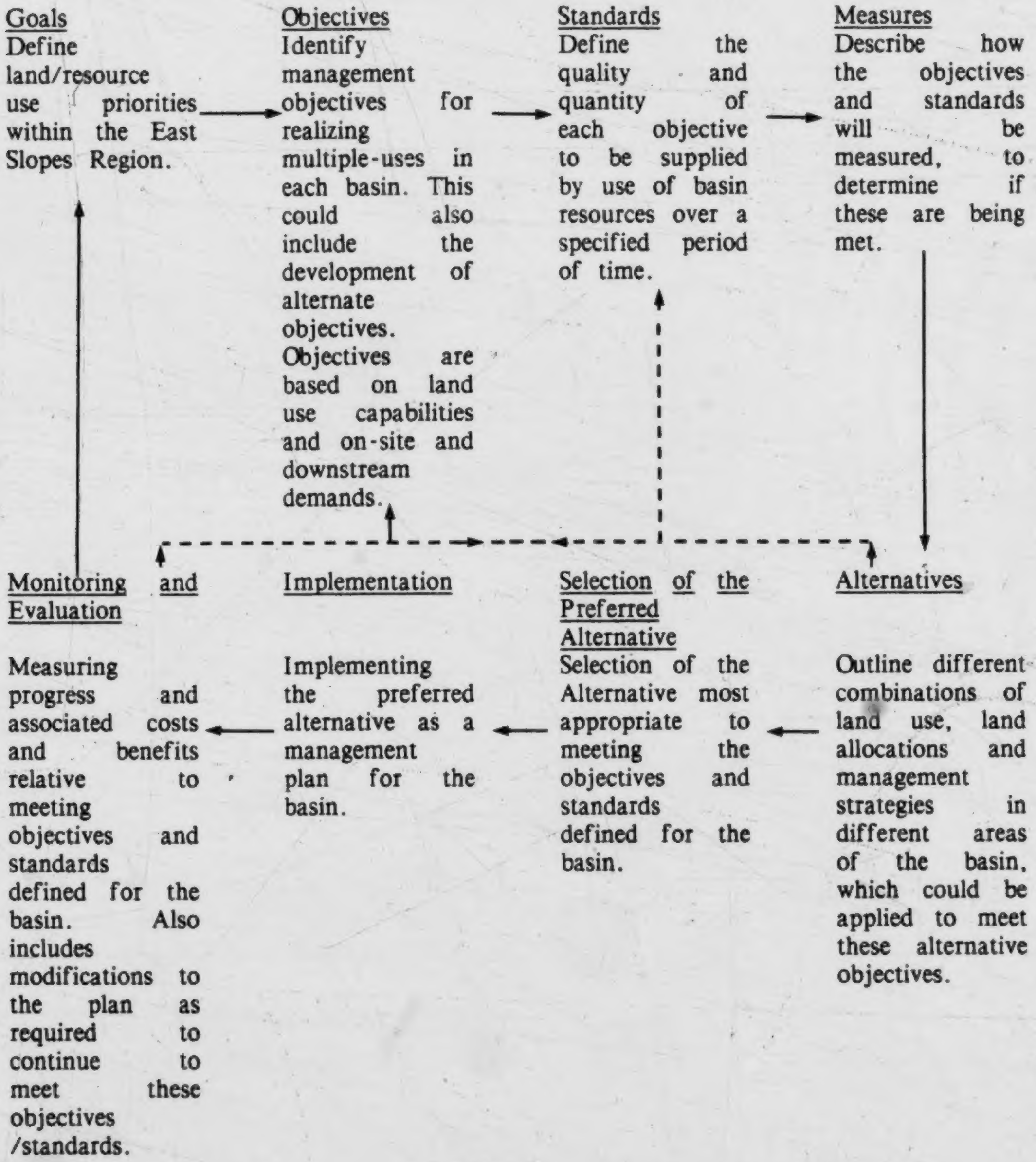
7.2.1 Management Goals

Goals are statements of desired results to be accomplished in very general terms, over an unspecified period of time (Parry, 1983). In the context of managing the East Slopes, goals would serve to identify the land or resource uses to be emphasized in the region and would provide some indication of the relative priorities of these uses (e.g. watershed in relation to other uses). Goals may also be used to provide some indication of the results expected, in very general terms, for each of the uses identified (e.g. protect wilderness values). On this basis, goals would provide overall direction and guidelines for land use and resource management within the East Slopes region. The definition of goals must be based on accurate resource supply and demand information. Formulation of goals which satisfy non-existent demands or goals which cannot be physically met (no resource capability) would not be realistic. Therefore, all goals must be defined within these limitations.

In the case of the East Slopes region, general supply and demand information is partially available. Extensive land capability (supply) information is available from many sources such as those outlined in chapter 3. Resource demand information is also available and this information has formed the basis for the East Slopes Policy. Demand is mainly defined by existing uses and the projection of these uses into the future. Public opinion information is also available. For example, in 1973, the Enrivonment Conservation Authority conducted hearings into "Land Use and Resource Development in the East Slopes," in order to identify the views and concerns of Albertans (Alberta Government, 1977; E.C.A., 1973). Briefs presented to the hearings and the results of a public opinion survey, strongly emphasized watershed and public recreation priorities (Alberta Government, 1977). The Government of Alberta essentially defined management goals on this basis, although it is difficult to assess how much of this information from the various sources was integrated and analysed to provide for sound decision-making. The East Slopes Policy statements could be considered as management goals for the region. The following exerpts from the East Slopes Policy document, referred to as general priorities and guidelines could be considered as goals under the integrated planning process (Alberta Government, 1977):

1. "The highest priority will be placed on watershed management to ensure a reliable supply of clean water for aquatic habitat and downstream users."
2. "The recreation potential and aesthetic quality of the mountains and foothills will be

FIGURE 10: THE PLANNING PROCESS



Goals
Define land/resource use priorities within the East Slopes Region.

Objectives
Identify management objectives for realizing multiple-uses in each basin. This could also include the development of alternate objectives. Objectives are based on land use capabilities and on-site and downstream demands.

Standards
Define the quality and quantity of each objective to be supplied by use of basin resources over a specified period of time.

Measures
Describe how the objectives and standards will be measured, to determine if these are being met.

Alternatives
Outline different combinations of land use, land allocations and management strategies in different areas of the basin, which could be applied to meet these alternative objectives.

Selection of the Preferred Alternative
Selection of the Alternative most appropriate to meeting the objectives and standards defined for the basin.

Implementation
Implementing the preferred alternative as a management plan for the basin.

Monitoring and Evaluation
Measuring progress and associated costs and benefits relative to meeting objectives and standards defined for the basin. Also includes modifications to the plan as required to continue to meet these objectives /standards.

Direct Path between Stages ⟶
Feedback Loop - - - - ⟶
(e.g. Objectives and Standards may be refined based on the results of the Monitoring/Evaluation Stage if this review shows that the objectives/standards are not attainable).
Source: Modified from Parry 1983. "Managing the Planning Process".

maintained, while increasing the opportunities of Albertans for enjoyment of this unique region."

3. "Critical wildlife habitat will be protected to maintain those species presently found in the East Slopes."
4. "Selected areas of natural significance that are unique or representative will be protected."
5. "The resources of the East Slopes will be utilized and developed, consistent with the principles of conservation and environmental protection."
6. "The management of renewable resources is the long-term priority of resource management in the Eastern Slopes. Non-renewable resource development will be encouraged where it is not in conflict with the long-term goal of renewable resource management."

Although the goals defined in the East Slopes Policy (1977) provide a logical first step in an integrated planning approach, how these goals are to be realized and to what extent, has not been given adequate consideration in the policy document. This major short-coming is shown in the move from goal formulation, directly into the plan stage (e.g. the zoning framework and management guidelines), without defining how the goals would be met in specific basins or defining the quantity or quality of resource use to be realized in each basin. Although management goals have been defined in the policy, the potential for local management conflicts within the East Slopes would be high, because priorities have not been set for the individual basins. How these goals will be met in relation to specific resource supply and demand patterns in the individual basins has also not been considered in the East Slopes Policy.

7.2.2 Resource Management Objectives

In the integrated planning process, the deficiencies noted above may be partially overcome by defining basin specific objectives.These objectives would specify how the goals might be achieved on a local basis, in relation to resource supply and demand patterns in each basin. Therefore, objectives are statements of specific results to be achieved in measurable terms, which relate back to the goals defined for the East Slopes Region. In other words, the objectives are used to define how specific goals will be met in each basin, in relation to specific resource demands and in relation to local environmental conditions and resource capabilities. There may be several objectives under each goal. For example, the goal of "managing the East Slopes watershed to ensure a reliable supply of clean water for aquatic habitat and downstream users" may require definition of several management objectives for each individual basin. These objectives may also change over a long period of time, in response to changing demand patterns or changes in environmental conditions in each basin. Since specific objectives are tied to resource supply and demand patterns within an individual basin, these objectives may differ considerably between basins. Factors such as local conditions, different opportunities for use and different demands, are responsible for these variations. However, all objectives should relate back to the goals defined for the region. (e.g. if watershed is the "prime" use, all objectives must be compatible with or complementary to watershed management goals).

For example, achieving the goal of "managing the East Slopes watershed to ensure a reliable supply of clean water for aquatic habitat and downstream users" may require objectives of yield improvement and flood control to satisfy downstream users in one basin, while objectives emphasizing regime improvement and the maintenance of water quality might be required to satisfy downstream users in another basin. However, both sets of objectives relate back to this same goal.

In the definition of basin specific objectives, all uses which have been identified in the goal statements and which are physically possible within the basin must be addressed. Possible uses include those which can be supported in the basin, (a reasonable capability to sustain use exists) and for which there is some potential demand. All management objectives must also be measurable, in order to determine whether the objectives and ultimately the goals, are being met within the basin and within the East Slopes region in general. Therefore, specific multiple objectives should be defined for each Each Slopes basin.

7.2.3 Measuring Objectives

The definition of measures provides the basis for evaluating progress towards the attainment of objectives. There can be several measures for each objective and the measurement criteria may range from very simple to very complex, depending on the objective. For example, if one of the defined management objectives is; to improve upon water yields, an appropriate measure might be the increase in mean monthly discharge, as measured by stream gauges located downstream. An objective of reducing forest fire losses might be measured by determining the actual number of hectares of forest burned over in the current year, then comparing this figure with the hectares of forest burned in the previous year(s). Some caution must be exercised in making such comparisons. In some cases, the measures may be very subjective (e.g. the measurement units may be simply "good," "fair," or "poor.") Some measures could relate to the amount of change, rate of change, or possibly amounts not related to change. Some common units of measurement cannot always be used and this may result in some problems of interpretation (e.g. comparing quantifiable and non-quantifiable information or determining what the information really means). Therefore, the degree to which measures are meaningful in management, may vary greatly. How these various measures are interpreted and applied, will be of considerable importance to the process.

Quantifiable measures should be applied to each of the stated resource management objectives, wherever possible. The measurement of performance, or the results actually achieved in relation to the objective, is essential to management. Monitoring and the evaluation of results is also required for the duration of the plan. This would require the development of information systems oriented towards measurement of specific changes. Therefore, measurement of results in relation to objectives, might require the establishment of ongoing information collection programs. This could involve ongoing monitoring and regular measurement of various components of the environment and analysis of this information to determine changes in conditions, with land use. This might include measurement of water quality, streamflow, changes in vegetation patterns, wildlife population, microclimate, erosion and many other variables. The information collected could be compared with baseline information, changes (negative and positive) could be identified and progress toward the attainment of basin specific objectives could be measured. This 'progress' could be assessed in relation to management objectives, to determine whether these objectives have been met. Different levels of monitoring might be required, depending upon the type of use and the extent of environmental impact or use conflicts possible.

7.2.4 Resource Management Standards

In order to measure progress towards the realization of management objectives; each objective must have a quantitative or qualitative component which can be measured, in order to determine if the objective is actually being met. Resource management standards are quantifiable statements of the level of resource output and/or environmental quality that is desired. The standard should also identify a time frame in which the objective or portions of the objective will be realized. For example, a 'standard' matched to an objective of yield improvement, might be to increase yields by 1% over five years. Therefore, the resource management standard is the management objective combined with the quantity or quality of output to be provided under that objective. As such, standards define an 'ideal'condition, but may or may not be possible due to resource limitations, or to the implications of other uses. Yield improvement is a good case in point. For example, if the increase is accomplished through cover management (e.g. forest cutting), the response is not cumulative. Yield increases would be greatest in the initial year, but would then decline. In five years, the actual increase in yields would be negligible, due to regrowth of vegetation. The yield increase could only be maintained at great expense and with little conjunctive return in terms of forest productivity. Therefore, these types of limitations may result in the standards not being met, or being met to a lesser extent than originally anticipated. On this basis, standards must also be reassessed at the 'alternatives' stage, in the process. The 'measure' component is applied to the standard to determine whether or not the standard has been met and ultimately, to determine if the objective has been met. This interrelationship is illustrated in the following example, which shows the progression from goals through objectives to standards, and the measurement of these objectives/standards:

Goal	Objective	Standard	Measure
To manage the East Slopes watershed to ensure a reliable supply of clean water for aquatic habitat and downstream users.	To increase stream yields in the upper North Saskatchewan Basin.	Increase yields by 1% over a 5 year period.	As measured by the mean annual discharge recorded at the Tershishner stream gauge.

7.2.5 Multiple Standards and Multiple Measures of Management Objectives

A standard and a method of measurement must be defined for each objective. Complex objectives may also require the definition of multiple standards and multiple measures. Multiple standards may be used to define conditions under which the objective must be realized, which would have to be accounted for in the development of alternatives at a later stage in the process. A multiple standard applied to the example might specify conditions to be maintained in the achievement of the objective. A corresponding measure must also be defined for each of these multiple standards. A hypothetical example showing multiple resource management standards and measures for an objective is shown below:

Objective	Standards	Measures
- To increase stream yields in the upper North Saskatchewan Basin.	- Increase yields by 5% over two years.	- As measured by the mean annual discharge - at the Tershishner gauge.
	- No more than 500 hectares of forest harvested in each year.	- As measured by the number of hectares cleared each year.
	- Stream sedimentation must not increase by more than 1%.	- As measured by water sampling downstream from the area harvested.
	- Fishery production must not decrease by more than 2%.	- As measured by test netting in downstream areas.

The definition of multiple standards and corresponding measures for each objective, permits an assessment of whether or not basin specific objectives are being met at predetermined points in time. In addition, it should be possible to determine if these objectives are being met within the conditions specified in the standards.

Multiple standards and measures could also be applied to multiple objectives. Management objectives for each use could be listed with appropriate multiple standards and measures and evaluated to identify potential conflicts on a preliminary basis. Land capability information could then be applied to assess the capability to meet each objective to the prescribed standard, within the basin. More detailed assessments may then be completed to determine the specific land units within the basin for each mixture of uses and the intensity of use possible therein. Alternative locations for various types, levels and combinations of land use activities and different management strategies to realize the objectives can be developed (see 7.2.7, Alternative Futures). Examples of multiple objectives, multiple standards and multiple measures are shown below:

Objective	Standards	Measures
- To determine the physical potential for maintaining or improving upon existing streamflow regime patterns.	- Maintain 'normal' monthly flows in relation to precipitation levels.	- As measured by stream gauges and compared to baseline information.
- To preserve wilderness values by allowing natural processes to occur unimpeded by man.	- No more than 5% of overmature stands to be allowed to burn over every ten years.[1]	- As measured by number of hectares burned, in ten year period.
- To maintain existing or improved streamflow regime patterns on the Cline River.	- No more than .5% increase in stream sedimentation.	- As measured by sediment levels derived from stream sampling and compared with baseline water quality information.
	- No alteration of streamflow regime as noted above.	- As measured by stream gauges, compared to baseline information.

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1. The extent and intensity of fire may vary significantly. Some areas may be burned-over repeatedly, while fire may never occur in other areas. The effect of fire upon regime and sedimentation may also vary greatly. For example in some areas, a 5% burn would have little effect, while in other areas, the effects would be devastating. These are examples of some of the problems with simplification of standards and measures into general statements. In practice, it may be very difficult to define actual standards which can be met or which can be effectively measured. This limitation to using the process outlined in this thesis,must also be recognized.

Multiple objectives can be cross-referenced to ensure that these are not conflicting and to ensure that the standards can be attained, without compromising other land uses. For example, it may not be possible to maintain 'normal' regime patterns under a management strategy which allows for up to 5% of overmature timber to be burned over in a ten year period. These types of environmental relationships and use limitations must be established, in order to identify potential conflicts between objectives and between standards, associated with various uses.

Although the merits of using this system as a basis for decision-making are apparent, a considerable volume of detailed baseline information is required. Use of this system would also require the collection of detailed management information on an ongoing basis, following any major change in use. This information must be in a form which can be compared against baseline information, in order to measure the degree of change (e.g. the change in stream yields following treatment of a basin). Additional information and analysis might also be required to determine whether or not changes are the result of natural processes (e.g. changes in streamflow resulting from differences in annual precipitation between wet, dry and normal years), or are actually the result of the management strategy. This type of information is very complex and could be difficult to obtain and interpret.

7.2.6 Collection of Management Information

At the present time, some level of baseline information is available for all East Slopes basins. In addition, varying degrees of ongoing environmental monitoring programs are in place in different basins. The extent of instrumentation required to provide an appropriate level of management information would vary between basins. Normally, this instrumentation could include networks of rain gauges, stream gauges and snow gauges, weather stations, and water quality monitoring, supplemented by ongoing forest and range monitoring programs, periodic inventories of wildlife and fisheries, as well as other programs. The network of instruments and degree of environmental monitoring is not always sufficient to collect accurate resource information on an ongoing basis. This deficiency is due to a small number of instruments deployed over a large area. This problem is compounded by extreme variations in conditions, over a relatively short distance, which is characteristic of all mountain watersheds. Extensive networks of instruments and ongoing collection of environmental information could be required in order to account for these extreme variations in environmental conditions. However, the extent of use changes would largely determine the need for close monitoring of environmental changes. This information must also be integrated to provide comprehensive management information which reflects ecological relationships within the basin. This level of information is desirable for management purposes in situations where major changes in use types, patterns, combinations, or intensities are proposed. For example, it might be impossible to identify the source of a 5% increase in stream yields or to assess changes in water quality resulting from the application of a management strategy, without some higher level of monitoring than is currently provided.

Collection and analysis of detailed information, although beneficial for decision making, is also a major limitation to the application of this system. The level of baseline data required, combined with the extensive environmental monitoring network and the need to analyze data on an ongoing basis following major land use change, would have high cost implications. In many areas of the East Slopes, collection of such detailed information may not be practical. Some compromise might be appropriate, whereby information could be collected from a smaller network of instruments and extrapolated to a larger area. This would still require a considerable increase over the existing level of environmental monitoring. However, the costs of either level of instrumentation could be relatively small in relation to the potential long-term benefits which might be realized, through more intensive monitoring, in situations where use changes have occurred.

For many East Slopes basins, such as the upper North Saskatchewan, fairly detailed baseline resource information is available, as outlined in chapter 3. However, a wide range of information such as surficial geology, soils, vegetation, micro-climate, wildlife, streamflow, water quality, land capability, resource demands and many other variables, must be integrated to provide adequate baseline information. This information must be analyzed to determine the relationships between various environmental components, in order to understand how environmental impacts associated with one resource use, might limit other uses. Secondly, it will be necessary to determine how various combinations and intensities of use interact. For example, if a 5% improvement in streamflow yield is to be realized, what is the best method of attaining this increase? If vegetation removal is stressed, how much timber must be cut and what level of increase in soil erosion could be expected? What would be the effects of other options, such as phreatophyte control or snow management, relative to improving yields? What would the environmental impacts of each option consist of, in relation to other land uses? This type of problem analysis would have to be completed for each objective and standard, in order to develop management strategies capable of meeting multiple-objectives.

The implications of each potential use and the way these uses are managed, must be evaluated in order to make rational land use and resource management decisions. The effects of use(s) on baseline environmental conditions and upon all other potential uses must be understood, in order to determine whether the standards for each of the various management objectives are realistic. This would provide the basis for developing alternative plans to meet each objective defined for the basin. For example, if a management objective is to increase stream yields to a standard of 5% over two years, is it possible to do this by harvesting less than 500 hectares of forest each year, while simultaneously maintaining a minimal increase in stream sedimentation and preserving a high quality fishery downstream? To answer these types of questions, the nature of impacts associated with various uses must be fully understood. Where possible, accurate estimations must be available, in order to project the impacts of various types and levels of use. These estimations should be compared with baseline conditions and with the conditions required to sustain other uses. On this basis, limitations to individual uses can be assessed in a multiple-use situation.

This model becomes even more complex, when several competetive uses are encouraged for the same land unit. In other words, complex relationships between several different uses under different sets of conditions, over time, would have to be considered. For example, hypothetical changes in the level of one resource use and subsequent changes in the level of other hypothetical uses, which would occur as the level (intensity) of each use changes in the model, must be evaluated. The following simple model is a description of the level of information required to facilitate the use of this process. If a 5% increase in streamflow is desired, based on existing vegetation, soil and precipitation relationships, and slope-runoff characteristics, it would be necessary to know how many hectares must be cleared to realize this increase. Further, it would also be necessary to know how much soil erosion and subsequent stream sedimentation could be expected, based on factors such as local soil conditions, drainage density, stream gradients and existing stream sediment loads. If a 5% increase in streamflow is required, resource managers would have to determine the number of hectares of forests to be cleared to realize this objective, as well as the associated costs in terms of increased erosion/sedimentation, potential reductions in water quality and fish habitat and the value of the timber produced. Limitations must also be considered. For example, this technique is rarely feasible unless the timber is reasonably mature and ready for some type of harvest. Timber prices also vary considerably between years, as does demand, and cutting may not be economically viable in some years. By establishing these and other fundamental relationships, resource managers should be able to predict and project potential impacts of each possible use and also determine potential limitations for each use and related management strategies, in a multiple-use situation.

It should also be possible to identify any potential resource limitations relative to sustaining multiple uses under various combinations and intensities of use. For example, it may be possible to realize a 5% increase in streamflow and maintain x level of environmental quality. However, if an x^1 level of environmental quality is desirable, it may only be possible to realize a 3% increase in streamflow, using the same management techniques. Interpretation of the data would also be of considerable importance in this problem analysis. For example changes between years could be attributed to many environmental and land use variables, such as natural variations in environmental patterns. Even with accurate measurement, considerable "guesswork" would be involved in interpreting these measurements for management purposes. However, despite these major limitations, potential conflicts can be identified and possible trade-offs evaluated, using this approach to problem analysis for resource management and land use planning.

7.2.7 Identification and Analysis of Alternatives

Objectives and standards for multiple resource uses could be realized through the application of several different management strategies, each incorporating different types and combinations of management techniques, land allocations and use guidelines. Each alternative developed for a basin represents a different method or strategy for meeting the objectives and standards, within the environmental limitations specific to that basin. Each alternative proposed, must be possible to implement within these environmental limitations, such as the capability of an area to sustain different levels and combinations of use activity. The alternative selected for implementation must also be appropriate to meeting the defined management objectives and theoretically, should also be appropriate to meeting the standards specified under each objective. Many alternative futures could also involve the definition of different objectives and standards, which may be valid in different economic or political situations. Changes in values through time, may make such alternatives equally valid. Factors such as resource demand patterns, both on-site and downstream (outside of the region) and pre-existing, long-term land allocations (e.g. an existing storage reservoir) must also be considered. In many instances these must be considered as 'given' factors, not subject to changes. In addition to this recognition of existing dispositions, the duration and time frame must be identified for all alternatives. This should specify how long the plan will remain in effect and what objectives will be met during this time period. Once alternative strategies for managing individual basins have been developed, the implications of various components of each alternative can be assessed, in relation to the objectives and standards. It is very possible that all of the alternatives will meet the objectives to some degree. However, it is also possible that none of the alternatives proposed will meet all of the standards specified for these objectives. Therefore, the alternative strategies must be assessed against the objectives and standards and these objectives and/or standards may require modification, if these cannot be met in a multiple-use situation. Trade-offs may be required on the basis of this assessment. For example, if one management objective is to harvest timber in an environmentally acceptable manner and the standard for that objective is to harvest 1,000 hectares of timber each year in a 20,000 hectare forest, a strategy for realizing this objective might involve block-cutting and replanting programs. However, if there is a second objective of maintaining the wilderness value of the area to a standard of minimal encroachment of man into the area, this strategy would not be appropriate to meeting both objectives. The standards and to a lesser extent the objectives in this example, could be mutually exclusive. It is also conceivable that parts of the basin or region may be physically or economically more suitable for specific uses. The preparation of detailed basin management plans and site specific studies would likely reveal that single objectives, standards, or management guidelines are not suitable for all areas. Therefore, the standards and policies would have to be reassessed and modified or expanded, with the appropriate trade-offs being made. For example, by reducing the timber harvest, relocating harvesting activity to other areas of the basin, or by modifying the wilderness management objectives, some degree of compromise should be possible. On the basis of these compromises or trade-offs, some degree of benefit could be derived from both uses. Therefore, conjunctive use could be possible through this integration of uses. Potential trade-offs identified in the review of alternatives could be used to redefine standards and possibly, to modify objectives, in order to ensure that these can be met within environmental or other limitations.

In some cases, it may be necessary to assign relative priorities to all potential uses. Some uses may be of equal value, while other uses may be emphasized or subordinated in importance relative to other uses. Priorizing uses may serve to establish guidelines for determining where trade-offs should occur. For example, management for a prime use should not be significantly compromised by the presence of secondary land uses. Similarly, secondary land uses should not be prohibited or overly restricted where there is little potential for compromizing management for the 'prime' use or in situations where conjunctive use is possible through the application of appropriate management strategies.

Since trade-offs will often be required, it would be advantageous to develop alternatives which emphasize various uses, to different degrees, and to propose different strategies for realizing the various objectives identified for the area. In some cases, the evaluation of alternatives may lead to changes to, or deletion of some management objectives, because the use combinations and/or levels proposed are not possible within environmental limitations.

Ideally, the assessment of alternatives would be based on detailed resource information. However in many cases, a good part of any such assessment would be very subjective. This problem is largely due to the fact that much of the resource information, especially information concerned with environmental quality, wilderness or wildlife values, is not usually quantifiable. Even if this information is quantifiable in general terms for each objective, the units involved are different, and any comparison must be subjective. In other cases, detailed resource information may not be available or it may not be possible to collect such information within realistic timelines or at an acceptable cost. These limitations may reduce the accuracy of any projections and therefore, estimates may be used to select the "best-fit" alternative. This is not an ideal method of selecting an appropriate alternative, but it may be an acceptable method in many cases. Although managers would not generally find perfect solutions in any situations, they should continue to attempt to find the best solutions to the resource management and land use problems at hand.

7.2.8 Selection and Implementation of the Preferred Alternative

Once the evaluation of alternatives has been completed and potential trade-offs have been identified, the most appropriate alternative should be selected for implementation. A comprehensive management strategy or plan, to remain in effect for a specified period of time (e.g. plan will remain in effect for 10 years), would be developed to implement the preferred alternative. This plan would involve the establishment of timelines for implementing the various components or programs included under the preferred alternative. The preparation of detailed guidelines for each resource management objective, would also be included in this phase. These detailed plans would include an outline of management strategies, techniques and land use guidelines to be applied in local areas within the basin to realize the objectives. An identification of when and how progress would be measured and evaluated should also be specified in the plan. The necessary monitoring infrastructure would also be put into place at this point, in order to measure the results actually achieved under this plan. Review and evaluation procedures and guidelines must also be established to ensure that the plan is flexible and can be modified as required by changes in baseline conditions or other factors. Once these tasks have been completed, the plan may be implemented.

7.3 Monitoring and Evaluation

Once the plan has been implemented, the impact of the plan should be monitored to measure the results actually achieved. The results achieved must be evaluated against the objectives and standards at predetermined intervals, in order to measure progress and to assess the need for possible changes to the plan. The collection, review and evaluation of environmental information and resource demand information, should allow resource managers to measure progress towards attainment of objectives and standards for each use. It should also be possible to identify any potential problems with one or more components of the plan, in relation to negative impacts. For example, if the plan calls for a 5% increase in streamflow as measured by a stream gauging network and this is achieved, the objective of stream yield improvement is being met to the established standard. Another objective may be; to maintain existing water quality. This objective could be measured by a water sampling program designed to collect water quality information which can be compared with baseline water quality information to detect changes. If a significant reduction in water quality was detected,, this might indicate that the increase of 5% in streamflow was being realized at the expense of the water quality objective. On the basis of this assessment, the plan would have to be reviewed and possibly amended, to ensure that the original objectives and standards continue to be met for the duration of the plan. Further trade-offs may be required at this point, if objectives are not being met to the specified standard, within acceptable timelines.

Analysis of information collected through the monitoring system would provide an indication of the effectiveness of the plan following major changes in use. The purpose of this evaluation stage is to assess the overall effectiveness of the plan in meeting specific objectives and standards and also to relate the overall basin plan back to the goals defined for the entire East Slopes region. The overall plan should be evaluated to 'review progress' at regular predetermined intervals. The outcome of the evaluation may indicate that the objectives and standards are being met to an acceptable level within established timelines. Alternatively, the evaluation may indicate that only some objectives and standards are being met, but that the environmental costs associated with these objectives and standards are higher than originally anticipated. This situation may require a change in the techniques used or require the establishment of additional management guidelines. In a situation where the plan is proven to be completly inadequate, the plan may have to be replaced by another alternative. In other situations, it may be appropriate to modify standards or redefine objectives, if it is shown that these exceed the capability of the environment to sustain certain uses or the levels of use specified in the standards. This review process would ensure that the management strategies contained in the plan continue to be effective and appropriate, in relation to both resource demand patterns and the capability of the resource base to meet these demands, for the duration of the plan. This flexibility is especially important when one considers that resource demands and to some extent resource supply, are dynamic concepts which may change naturally through time. Supply and demand relationships may also change as a result of limitations to individual uses, in a multiple-use situation. In any long-term plan (e.g. greater than 20 years), the ability to respond to potential changes is especially important, if the goals, objectives and standards (or revised objectives and standards) are to continue to be met through time. Near the end of the term of the plan, the process may be initiated again, with objectives redefined in relation to the environmental conditions, supply and demand patterns and social, cultural and technological conditions in place at that time.

7.4 Practical Application to Resource Management and Land Use Problems

The procedure outlined by the author in this chapter should be regarded as a method for problem definition and for developing alternative solutions to problems, rather than a set of objectives and standards that one would expect to achieve fully. In practice, the attainment of complex, potentially conflicting objectives, using a rigid model such as the process outlined in this chapter, is unlikely. The process would not be desirable, if it became too inflexible and could not be modified in response to change. However, using such an approach is still advantageous. Exposure to this type of approach might serve to 'condition' managers and planners involved, to use as 'scientific' an approach as possible, so that they may be as objective as possible in their decision-making, or in the submission of their material to politicians for decision-making. The multiple-use, alternative futures process described in this thesis, despite its many limitations, can be useful in promoting this degree of objectivity and could result in a more efficient use of the resources of the upper North Saskatchewan Basin and other basins.

8. Application of the Multiple-Use Approach for the Development of Alternative Management Strategies for the Upper North Saskatchewan Basin

8.1 Introduction

The objective of the author in this chapter is to apply the planning framework described in chapter 7 to a hypothetical situation, in order to illustrate its potential applications. This framework will be used to describe an alternative procedure for watershed planning and problem solving, using the example of potential land use and resource management conflicts in the upper North Saskatchewan Basin. A very basic outline and level of analysis has been used in this exercise, as the preparation of a detailed plan is considerably beyond the scope of this thesis. The main limitation to completion of both a detailed management plan and the hypothetical plan in this thesis, is a lack of resource supply and demand information, upon which sound management decisions can be made. Where such deficiencies exist, the author will describe the type of information required. Goals, objectives and hypothetical standards will be proposed for the study area and potential alternatives will be developed to meet these goals, objectives and standards. At the 'alternatives' stage in this process, alternative management strategies (alternative futures) will be outlined and the implications of each strategy will be assessed in relation to current resource management and land use trends in the Basin. The degree to which various uses may be optimized under each alternative will also be evaluated. However, it should be noted that the use of a process such as the one used by the author in this thesis, is not a perfect solution to potential resource management and land use problems. Some degree of conflict will always occur, but through comprehensive, integrated planning, the extent of such conflicts could be reduced considerably. Greater resource benefits might therefore be possible for both on-site and downstream users, in the long-term.

However, the use of this process may also involve considerable costs. The extent of information required and the need for closer monitoring and constant updating of this information are perhaps the main limitations to the use of this approach. Development of any integrated, multiple-use management plans for the upper North Saskatchewan, or other East Slopes basins, using this or any other similar, multiple-use process, would require a considerably greater level of detail than is required under the current 'single-use' strategy, as described in the East Slopes Policy (Alberta Government, 1984; 1977). This would include more detailed demand information, better environmental capability information, and a much greater understanding of how the resource base responds to different types, combinations, and intensities of land use and different management techniques.

8.2 Resource Management Goals and Priorities

The goals governing land use and resource management in the East Slopes, as outlined in chapter 7, are used to define broad principles and priorities for resource allocation and use. These goals would apply to the upper North Saskatchewan Basin on a generalized basis. Basin specific objectives should be developed on the basis of goals and related guidelines. The relative priorities of these objectives should also be established to reflect these goals. For the purposes of this thesis, the general priorities and guidelines outlined in the East Slopes Policy and described in chapter 7, will be used as the resource management goals and priorities to be applied to the upper North Saskatchewan Basin. These 'goals' are listed below (Alberta Government, 1977).

1. "The highest priority will be placed on watershed management to ensure a reliable supply of clean water for aquatic habitat and downstream users."
2. "The recreation potential and aesthetic quality of the mountains and foothills will be maintained, while increasing the opportunities of Albertan's for enjoyment of this unique region."
3. "Critical wildlife habitat will be protected to maintain those species presently found in the East Slopes."
4. "Selected areas of natural significance that are unique or representative will be protected."

5. "The resources of the East Slopes will be utilized and developed, consistent with the principles of conservation and environmental protection."
6. "The management of renewable resources is the long-term priority of resource management in the East Slopes. Non-renewable resource development will be encouraged, where it is not in conflict with the goal of renewable resource management."

Watershed is identified as the highest priority for the entire region, including the upper North Saskatchewan Basin. (Alberta Government, 1984). It may be assumed that the other goals are of somewhat lower priority. Other goals (e.g. recreation or wildlife) would be considered generally to be of equal value, with some uses being given a higher priority locally (e.g. wildlife higher than recreation). However, these goals would never have a higher priority than watershed. Objectives and standards would be developed to meet these generalized goals within the study area. These objectives and standards would be based on existing land capabilities, existing and potential resource demands, and on the potential to realize these demands through the application of management strategies within the Basin. Alternatives may then be developed which will reflect these generalized goals and priorities, through the specific objectives and standards defined for the Basin.

8.3 Resource Management Objectives and Standards

8.3.1 Defining Objectives and Standards

Objectives and standards may be defined for the upper North Saskatchewan Basin, in relation to the capabilities of the Basin to support various uses and existing and potential demands for those uses. These capabilities and demands have been assessed for both watershed and park purposes, in chapters 4 and 5. Watershed management objectives were defined on the basis of both on-site requirements for hydro-power production, downstream demands for water supply and pollution assimilation, as well as onstream, instream, and stream-side uses, within the region. The physical opportunities for improvement through management have also been considered, taking into account the existing and potential operational requirements of the Bighorn Dam and the potential for inter-basin water transfers. Park management objectives were defined in chapter 5, based on the presence of provincially significant landscapes and resources within the Basin, as well as existing and potential recreational use. Therefore, multiple-objectives have been defined for watershed and for park management. Other objectives are also possible and should be defined for all possible uses of the upper North Saskatchewan Basin, implied in the goals defined in the East Slopes Policy. The following objectives will apply to the upper North Saskatchewan Basin for the purpose of this thesis:

Watershed Management Objectives

- To improve upon the existing seasonal distribution of streamflow (regime improvement) to facilitate increased on-site power production and greater augmentation of streamflow during the winter months.
- To effectively manage land use activity within the Basin, to minimize soil erosion and stream sedimentation.
- To maintain existing levels of water quality.
- To maintain acceptable streamflow yields, in relation to regime improvements.

Park Management Objectives

- To preserve the environmentally sensitive terrain and valuable aesthetic resources of the Basin and to preserve provincially significant landscapes.
- To provide for a wide range of dispersed and concentrated outdoor recreation activities within a natural setting.
- To maintain existing quality of wildlife range and habitat within the Basin.
- To preserve the wilderness values and ecological diversity of the Basin.

8.3.2 Application of Standards

Standards may be applied to each of the objectives, based on an assessment of the potential of the Basin to meet each objective and the potential for conflict between objectives, as was described in chapter 6. Since detailed resource information is not available, standards developed for these objectives should be considered as examples only, and are not based on any quantifiable information or proven facts. Multiple standards have been developed for many of these objectives, to illustrate the complexity of the process. Many other standards might also be possible. These multiple standards are used to define the conditions under which the objectives must be met. Some of these multiple standards are the same for both sets of objectives and therefore, some duplication of standards may occur under different objectives. The following standards attached to each of the objectives specified, may be used as examples for the upper North Saskatchewan Basin.

Watershed Management

Objectives	Standards
- To improve upon the seasonal distribution of streamflow (regime) to facilitate increased on-site power production and increased augmentation of low streamflow during the winter months.	- Increase winter flow by 5% through increased releases from storage.
	- Increase hydro power production capability by 10% during the winter peak demand period. Maintain existing production during other months.
	- No increase in flood hazard downstream.

Objectives	Standards
- To effectively manage land use activity within the Basin, to minimize soil erosion and stream sedimentation.	- No more than a 2% increase over natural erosion is acceptable (Assuming this is within the range of soil formation exceeding mass wasting).
	- Stream sedimentation must not increase by more than 5% over present sediment yields.
	- All existing and potential land uses must not increase erosion or sedimentation above the natural process rates (e.g. rates under a 'no-use' situation).
- To maintain existing levels of water quality.	- No unnatural, negative changes in chemical or bacteriological quality of any streams or lakes within the Basin.
	- No deterioration in the existing level of fish productivity in any stream or lake within the Basin.
- To maintain acceptable streamflow yields, in relation to regime improvements.	- No significant reductions in total annual water yields, greater than x% should occur due to the application of any watershed management programs oriented toward regime improvement.

Objectives	Standards
- To preserve environmentally sensitive terrain and valuable aesthetic resources in the Basin.	- No development in environmentally sensitive areas having a low capability to sustain use. - Developments must not significantly detract from the aesthetic qualities of the Basin. - Construction must be completed in a manner which minimizes negative environmental impacts.

Objectives	Standards
- To provide for a wide range of dispersed and concentrated outdoor recreation activities within a natural setting.	- Campgrounds would be developed in response to demands, up to a maximum of 600 auto-access sites. - Backcountry hiking and equestrian opportunities will be provided in response to demand. - Downhill ski area development may be considered where sufficient demand, terrain and snow conditions exist, with no more than 100 hectares of the Basin being utilized for such development. - Recreational use must not compromise wildlife range. - Recreational developments and use must not result in significant deterioration of watershed conditions. - Recreational developments must not result in deterioration of existing water quality or reduction in fish productivity. - Recreational developments must not result in increases in erosion/sedimentation above the specified standard.

Objectives	Standards
- To maintain existing quality of wildlife range and habitat within the Basin.	- No major reductions in the size of grassland areas, resulting from maturing vegetation (succession) due to protection programs (e.g. fire control). - No significant negative impact on wildlife should occur due to recreational use or watershed management programs. - Ungulate population to be maintained at a level below x number of moose, deer, and elk. - Accelerated soil erosion resulting from ungulate overgrazing or overbrowsing is not acceptable.
- To preserve wilderness values and ecological diversity.	- Wilderness values will be maintained in selected areas of the Basin. - Natural environmental processes will be allowed to continue wherever possible, in selected areas of the Basin. - Watershed conditions must not deteriorate significantly through fire, insect infestation or tree disease.

8.3.3 Balancing Objectives and Standards

The objectives and standards defined for the upper North Saskatchewan Basin outline the general conditions that must be met by the various alternatives, described later in this chapter, in section 8.6. Each objective and the standards included under each objective, must be met, without compromising the other objectives, or the standards for these other objectives. For example, if winter flow is increased by 5%, through increased releases, this must be accomplished without any deterioration in water quality upstream and without any increased flood hazard downstream. Similarly, any land use, such as development of recreational facilities, must not significantly increase erosion and stream sedimentation; must not reduce water quality; have a negative impact on wildlife; or alter natural environmental processes. Standards may be used to define how much of a given land use activity may be permitted; identify how much improvement in resource conditions or resource output is required, and specify the conditions and/or limitations under which the objectives must be met.

All alternatives developed for the Basin should meet the defined objectives and all standards associated with those objectives. On this basis, objectives and standards may be used as guidelines for developing alternatives. Standards provide a series of checks and balances for the realization of objectives. By balancing these objectives using multiple standards, it should be possible to achieve a much higher degree of resource management and land use integration. The definition of objectives and standards for each resource use should permit a more complete utilization of the lands and resources of the upper North Saskatchewan Basin, with fewer conflicts between uses. It must also be stressed that the examples used in this hypothetical plan might not be adequate for use in actual plans. Any actual management plans prepared for the upper North Saskatchewan Basin should be "all inclusive" and must be based upon a much better definition of objectives and standards, using sound biophysical and economic data.

8.4 Measurement of Objectives and Standards

8.4.1 Defining Appropriate Measures

Before alternatives can be developed for the upper North Saskatchewan Basin, decision-makers must have some method of measuring results, in order to determine whether the objectives and standards are being met. Therefore, measures must be defined in order to measure changes or deviations from baseline conditions or changes in resource productivity. Each standard should be measurable, in order to determine if the plan or various components of the plan are meeting these standards and ultimately, meeting the objectives defined for the Basin.

Measures may take many forms. Some variables such as streamflow, are easily measured in quantifiable terms. For example, by determining existing streamflow and developing a monitoring system to detect increases or decreases in yields, changes in streamflow can be measured. Increases or decreases in yield, beyond those of expected annual variations, may be the result of a particular management strategy applied within the Basin. However, it is often difficult to determine how much of the change is due to use changes and how much is due to climatic variations. On this basis, any change in yields sufficient to meet the standards and accomplished within the standards for other objectives, could indicate that the strategy applied is effective in obtaining the desired results. This would require actual measurement of the change and a recognition of possible variables, in any interpretation of this information. Although it is possible to measure these types of environmental change, other changes involving variables such as wilderness values and other non-quantifiable intangibles are considerably more difficult to measure. In these situations, quality statements may have to be drawn up to define the conditions that should be maintained (e.g. a detailed definition of wilderness). Visual comparisons through time may provide some indication of positive or negative aesthetic changes in relation to the defined conditions. These qualitative statements could be assessed along with the quantifiable information, obtained through actual measurement, to determine the extent of changes in a large number of environmental variables following a major use change. This could be used to measure overall conditions in the Basin, in relation to established standards, at predetermined points in time. This could also provide the basis for assessing progress toward the realization of defined objectives and standards. Positive and negative aspects associated with this progress could also be identified. Various methods could be used to measure different components of the environment which might be affected by the application of a management strategy. Hypothetical measures described by the author of this thesis are listed below. These measures have been developed for each of the standards. The measures listed are provided as examples only and other additional measures or different methods of measurement could also be used.

Standards	Measures
- Increase winter flows by 5% through increased releases from storage.	- Existing winter flows established by measurement at Bighorn Dam. Increased flows would be measured at Bighorn and compared with baseline data to establish % increase.
- Increase hydro-power production by 10% in winter peak demand period. Maintain existing production during other months.	- Existing power production is known. Any increases can be measured and assessed against existing production to determine % increase.
- No increase in flood hazard downstream.	- Establish a network of stream gauges downstream from Bighorn, to establish 'normal' streamflow and to determine variations expected between wet and dry years. Measure changes in streamflow and water levels following increased flow regulation to determine the extent of any increased flood hazard. In winter months, measurement of flow would have to be taken at Bighorn and the hazard assessed, based on studies of ice damming problems downstream.

Standards	Measures
- No more than 2% increase over natural erosion is acceptable.	- Determine existing erosion rates under natural conditions and existing land use, to establish baseline conditions. Establish and monitor representative test sites within the Basin to determine changes in erosion rates.
- Stream sedimentation must not increase by more than 5% over present sediment yields.	- Implement a water sampling program to establish existing sediment yields in different areas of the Basin. Continue program of periodic sampling to measure changes in sedimentation from the baseline level.
- All existing and potential land uses must not increase erosion or sedimentation above the natural process rates (e.g. rates under a 'no-use' situation).	- Changes in erosion and sedimentation as measured by the methods previously noted, following a change in land use.
- No unnatural, negative changes in chemical or bacteriological water quality of any stream or lake within the Basin.	- Implement water quality monitoring program throughout the Basin to sample water for analysis, to determine baseline conditions. Continue sampling program to identify any negative changes in water quality.

Standards	Measures
- No deterioration in the existing level of fish productivity in any stream or lake within the Basin.	- Implement a test netting program in the Basin to determine species, numbers and productivity. Continue program to detect changes in these conditions, following land use changes or application of resource management programs.
- No significant reductions in total annual water yields, greater than x% should occur due to the application of any watershed management programs, oriented toward regime improvement.	- Determine existing stream yields as measured by gauging stations and measure any changes in total yields by comparing annual streamflow between years (after adjusting for wet/dry years) to determine any changes following application of a watershed management program.
- No development in environmentally sensitive areas, having a low capability to sustain use.	- Conduct studies to identify these areas within the Basin. Any development which occurs in these areas would mean this standard is not being met.
- Development must not detract from the aesthetic qualities of the Basin.	- Quality statements are required to describe the aesthetic conditions to be maintained. Developments which detract from the conditions described in the statement, would not be appropriate under the standard.

Standards	Measures
- Construction must be completed in a manner which minimizes environmental impact.	- A maximum acceptable level of environmental impact must be defined. Potential impacts of various construction methods would be evaluated against this maximum acceptable level.
- Campgrounds will be developed in response to demands and within land use limitations, up to a maximum of 600 sites.	- Existing use and potential demands must be measured to determine the need for additional sites and potential campground locations. Demand may be measured by comparing existing use with available facilities to determine overuse and unacceptable environmental deterioration.
- Backcountry and equestrian opportunities will be provided in response to demands and within land use capabilities.	- The impact of existing use would be evaluated to determine limitations to existing and potential use (carrying capacity). Increased impacts associated with additional use and development might then be estimated and appropriate measures taken to minimize potential impacts. (e.g. formalization and upgrading of trails to reduce erosion, setting use limits, etc.)

Standards	Measures
- Downhill ski area development may be considered where sufficient demand and appropriate terrain and snow conditions exist. No more than 100 hectares of land may be utilized for such development.	- Standard sets planning guidelines. Demand may be measured and terrain and snow conditions evaluated to identify potential sites. Limitation of 100 hectares concentrates disturbance into one area of the Basin. Potential impact on baseline watershed conditions could be assessed to "measure" level of impact prior to development.
- Recreational use must not compromise wildlife range.	- Baseline wildlife range conditions and key range would be identified and potential recreational impacts evaluated against those conditions to determine degree of impact. Existing use could also be evaluated against baseline range conditions to measure positive or negative effects on wildlife.
- Recreational developments and use must not result in a significant deterioration in watershed conditions.	- Establish a measure(s) for baseline or ideal watershed conditions. Assess potential impacts of proposed recreational developments and actual impacts of existing use, and compare this against baseline conditions to measure potential deterioration in watershed conditions.

Standards	Measures
- Recreational developments must not result in a deterioration of existing water quality or significant reduction in fish productivity.	- Establish baseline water quality and fish productivity levels. Determine possible impacts of recreational use (and other uses). Monitor water quality and fish productivity to measure unnatural changes from the baseline conditions.
- Recreational use and developments must not result in erosion/sedimentation rates above a specified level.	- Existing erosion and sedimentation rates must be established. Impacts of recreational use and facility development must be determined and assessed against the baseline data to measure potential increases. Methods of determining combined effects of all land use activities in the Basin must also be developed.
- No significant reduction in the area of grasslands (within the valley zone) resulting from maturing vegetation (succession) due to protection programs (fire control).	- Measure existing area of grassland in the zone. Determine what the maximum acceptable reduction in area might be. Evaluate land use proposals against this baseline information to determine if a significant reduction in grassland area would occur.

Standards	Measures
- No significant negative impact upon wildlife should result from recreational use or watershed programs.	- Determine potential impacts of these activities upon wildlife and identify thresholds above which negative impacts occur. Compare actual or potential effects of use against the established thresholds to measure level of impact.
- Ungulate population to be maintained at a level below x number of moose, deer, and elk.	- Establish carrying capacity for ungulates for the Basin and determine the optimum number of animals. Conduct periodic inventories to measure population in relation to this optimum number.
- Accelerated soil erosion resulting from ungulate overgrazing and overbrowsing is not acceptable.	- Determine carrying-capacity of soil to sustain use, evaluate existing erosion rates and measure changes with ungulate use or changes following the application of management or improvement programs.
- Wilderness values will be maintained in selected areas of the Basin.	- Define wilderness values, identify specific areas, define conditions that must be maintained to meet these values, assess potential impacts of land use or management strategies upon these conditions to measure potential impact on values.

Standards	Measures
- Natural environmental processes will be allowed to continue unimpeded, wherever possible, in selected areas of the Basin.	- Determine existing conditions in the Basin. Determine the relationship of natural processes to the 'optimal' conditions required for all uses. Assess potential implications of this strategy on other land uses. Determine feasibility of maintaining natural processes in different areas of the Basin. Measure changes in conditions resulting from natural processes.
- Watershed conditions must not deteriorate significantly through fire, insect infestation, or tree disease.	- Determine the actual effects of fire and disease on streamflow. Calculate maximum acceptable land area which can be burned or infested (and the location of these areas in the Basin) before significant damage occurs. Measure extent of areas burned or infested to determine damage potential. Estimates may be used to determine if action should be taken to suppress fires or control infestations, which may cause damages beyond a predetermined level.

Most of the measures suggested by the author are subjective to some degree. However, this level of definition is considerably greater than any measures currently being used to evaluate the effects of land use change or resource management activities. At present, very little attention is given to measuring changes occurring through use or management and consequently, the actual implications of a land use or resource management plan may not be known until significant environmental deterioration or use conflicts have occurred. Therefore, more definition of this nature is badly needed and more monitoring would be highly desirable.

8.4.2 The Need for Monitoring and Evaluation Programs

Without monitoring and evaluation it would be impossible to measure progress toward the attainment of defined goals, objectives, and standards. It would also be impossible to evaluate the effectiveness of the alternative selected for managing the resource supply of the Basin, to meet a wide range of existing and potential demands. Potential land use and resource management conflicts would be difficult to predict and in some cases, impacts could not be assessed until after serious damage had occurred. Without knowing if the objectives and standards are being met, it would not be possible to adjust the strategy to ensure that these objectives and standards can continue to be met, for the duration of the plan. Therefore, the function of monitoring and evaluating progress on an ongoing basis, and having the capability to adjust or modify various components of the plan, is essential to meeting the defined objectives and standards.

Establishing an agency of similar responsibility and authority to that held by the Eastern Rockies Forest Conservation Board (E.R.F.C.B.) might be a viable option for performing this role. The present situation, whereby a number of different provincial government departments administer various areas of the Basin in relative isolation from each other, does not seem effective. It is logical to assume that such an administrative arrangement would not be sufficient to manage a comprehensive integrated resource management and land use plan in the upper North Saskatchewan Basin. A 'central agency' (preferably without vested interest) could serve to coordinate the activities of other agencies in the Basin. Such an agency could be responsible for the formulation of alternatives, selection of the preferred alternative and implementation of this alternative as the plan, as well as having responsibility for the coordination of all monitoring, evaluation, and modification of the plan. Other agency structures or organizational arrangements might also be possible and should be investigated further. For example, stronger Regional Planning Commissions might be capable of performing this coordinating function. A better definition of reporting lines and interdepartmental relationships relative to land and resource management might also serve to minimize "vested interests" and provide for more flexible approaches to management. Changes in Department responsibilities and amalgamation might also have some benefits, if all resource agencies (e.g. Public Lands, Forest Service, Parks, and Water Resources) were within the same Department.

8.5 Development of Alternative Management Strategies

8.5.1 Relationship of Alternatives to Objectives and Standards

Following the definition of goals, objectives and standards for the upper North Saskatchewan Basin and the establishment of a system to measure and evaluate progress towards attaining these, alternative methods of meeting the objectives and standards can be developed. The underlying condition governing all alternatives, is that each must be capable of being implemented and each must be capable of meeting the goals, objectives and standards defined for the Basin. Within these limitations, alternatives can be developed which outline different combinations, levels and priorities of use, as well as different resource management and development strategies.

8.5.2 Components of Alternative Management Strategies

Several different management strategies could be developed for possible application in the upper North Saskatchewan Basin. Each of these alternatives could include different levels of development and combinations and intensities of land use, different land allocations and designations, and different management guidelines. Despite these potential differences, all alternatives proposed must be appropriate to meeting the objectives and standards defined for the Basin. This condition effectively narrows the range of alternatives possible, and serves to eliminate alternatives of an incompatible nature from further consideration.

Four alternative management strategies are proposed by the author in this chapter. These alternatives represent a fairly narrow range of options. All four should be appropriate in relation to meeting the defined objectives and standards. It must also be recognized that other alternatives could be possible, but any detailed consideration of a large number of alternatives is beyond the scope of this thesis. In addition, different methods of formulating alternatives could be used. For example, stronger Regional Planning Commissions could also formulate alternatives and coordinate implementation, monitoring and evaluation, using common guidelines. Discussion of these other methods has not been included in this thesis.

The alternatives described in this chapter include the following: Alternative I (Watershed Management Emphasis), Alternative II (Outdoor Recreation Emphasis), Alternative III (Wilderness Conservation Emphasis), and Alternative IV (East Slopes Policy Emphasis). In each alternative, watershed is recognized as the 'prime use', based on the goals defined for the Basin in the East Slopes Policy. The degree to which secondary land uses are emphasized in relation to watershed, differs under each alternative. For example, in Alternative II (Outdoor Recreation Emphasis) and Alternative III (Wilderness Conservation Emphasis) some potential watershed benefits might be traded-off, in order to facilitate other land uses. The degree of trade-off permitted, must not be sufficient to impair conditions required to meet the watershed management objectives defined for the Basin, or be sufficient to prevent the application of required watershed managment techniques. In Alternative IV (East Slopes Policy Emphasis), continuance of the existing management strategy, as outlined in the East Slopes Policy, is emphasized. In all alternatives, existing land dispositions such as the Bighorn Dam, Kootenay Plains Natural Area and the White Goat and Siffleur Wilderness Areas are assumed to be 'given' factors. Therefore, the pre-existence of these dispositions is recognized in each alternative. The size of these dispositions and how these are managed are considered to be variable factors, which could differ under each alternative. For example, the management guidelines applied to Abraham Lake or to the Kootenay Plains and the degree of conjunctive use possible in these sites would be considered as variables under each alternative.

Multiple-use is emphasized under all four alternatives. The type and intensity of use proposed and the degree to which these uses are integrated may vary between alternatives. In addition, uses such as forestry, agriculture, grazing and oil and gas production, have been excluded from consideration, recognizing that the Basin has a very marginal capability to sustain such uses. Therefore, the Basin has the physical capability to sustain all uses considered in these alternatives. In addition, there is some existing or potential demand for each of these uses, either within the Basin, or downstream within the region.

8.5.3 Alternative I (Watershed Management Emphasis)

Under this alternative, watershed management for regime improvment and water quality maintenance is recognized as the prime use of the upper North Saskatchewan Basin, with all other uses being of subordinate importance. On this basis, development of secondary uses must not compromise the required watershed conditions, or limit the application of any required watershed management strategies, including structural options or environmental modifications. Therefore, allowances may be made for secondary uses, but only where these uses and the related management strategies are compatible with or complementary to the watershed management objectives defined for the upper North Saskatchewan Basin. All other uses deemed to be incompatible with these objectives would be prohibited. For uses deemed to be compatible, the extent and intensity of use would be controlled, to minimize the impact on watershed conditions. Ideally, land allocations to secondary uses should be limited where there is a potential for these allocations to conflict with management of lands for watershed purposes. However, extreme land use restrictions may not be practical and various degrees of compromise between watershed and other uses could occur, in order to ensure maintenance of the required watershed conditions.

8.5.4 Alternative II (Outdoor Recreation Emphasis)

Under this alternative, the upper North Saskatchewan Basin would still be managed for watershed purposes, however much greater emphasis would be placed on outdoor recreation than in Alternative I. To this end, some degree of watershed protection and some watershed benefits, both on-site and downstream might be traded-off, in order to facilitate increased use and management for outdoor recreation. Management strategies required for outdoor recreation would be modified where required to ensure compatibility with watershed objectives. Watershed requirements would also be emphasized in all outdoor recreation planning and construction of facilities would emphasize minimum environmental impact. Natural resource conservation and the protection of significant resources would be a high priority under this alternative. There would also be some emphasis placed on the provision of access to these features, for the use and enjoyment of visitors to the area. Where there are clear conflicts between recreation and watershed, recreation will be subordinate to watershed, only where no other compromises are possible. However, every effort would be made to obtain optimum benefits from both uses. Land allocations appropriate to outdoor recreation and conservation objectives would be considered, but any management strategies applied on lands so allocated, must also ensure that watershed requirements are met. Therefore, very flexible land and resource management would be necessary, in order to meet the requirements of both watershed and outdoor recreation objectives.

8.5.5 Alternative III (Wilderness Conservation Emphasis)

Under a pro-wilderness alternative, portions of the upper North Saskatchewan Basin would be managed to maintain natural environmental processes and to preserve the wilderness character of much of the area. Although watershed would still be emphasized to a high degree, the application of structural watershed management options, such as additional on-stream storage and snow pack management, would only be considered as a last resort. Management options emphasizing less environmental modification (e.g. modification of demand downstream, optimal use of existing storage, etc.) would be preferred under this alternative. Natural resource protection and conservation would also have a high priority under this alternative, but management of these resources would not include the provision of auto-access to these features.

Outdoor recreation facility development and the development of sites outside of the valley zone would not be appropriate under this alternative. Informal backcountry use would be favoured, with minimal development in staging areas and no development in wilderness areas. Use controls would be considered where deterioration of the resource was possible. Therefore, Alternative III would place considerable limitations upon outdoor recreation development in the Basin.

Some watershed benefits might be traded-off to ensure some degree of wilderness protection. Complementary watershed management strategies and wilderness management strategies might be developed to ensure benefits of both uses. Such strategies would have to include consideration of potentially conflicting issues, such as fire control policy and limitations to ungulate range, resulting from maturing vegetation. Balancing the requirements for wilderness with watershed objectives would be required. However, as in all alternatives, watershed management would take precedence in the Basin. Wilderness values would be strongly considered in the development of watershed management strategies and in any application of watershed management techniques. Land allocations appropriate to meeting wilderness objectives would be encouraged, providing that the management guidelines accompanying such allocations, remain flexible enough to ensure adequate watershed protection. These guidelines must also be flexible enough to permit the application of watershed rehabilitation measures or improvement programs, where required.

8.5.6 Alternative IV (East Slopes Policy Emphasis)

Under this 'maintain the status-quo' alternative, land use and resource management within the upper North Saskatchewan Basin would continue along present lines, with the management guidelines contained in the East Slopes Policy and Rocky-Clearwater Management Overview, being applied. Under the East Slopes Policy (1984), somewhat greater emphasis would be placed upon commercial tourism and a wider range of recreational activities. Lands within the Basin would be allocated to specific uses and managed accordingly for either 'general recreation' or 'prime protection' purposes (Alberta Government, 1984). Watershed is identified as the 'prime use,' with management emphasis placed upon outdoor recreation in the general recreation zone and upon environmental conservation and limited recreation in the prime protection zone (Alberta Government, 1977; 1984). The only watershed strategy proposed for the North Saskatchewan Basin, is to maintain natural flows and provide the option for future increases in water yield, through intensive management (Alberta Government, 1984). No actual details are given as to how this strategy is to be applied in relation to other objectives within the 'prime protection' or 'general recreation' components of the upper North Saskatchewan Basin (Alberta Government, 1984). An outdoor recreation and environmental management strategy is proposed in the East Slopes Policy, however there is no assessment of how this strategy impacts upon watershed conditions, or limits the application of watershed management programs in the Basin. Therefore, it is assumed by the author that; the Basin would be managed for resource conservation and outdoor recreation purposes, with watershed management strategies and programs being applied on an 'as required' basis. It is also assumed that this action would be taken, irrespective of any resource conservation or outdoor recreation objectives or related land allocations. Therefore, it is likely that any trade-offs between outdoor recreation and resource conservation objectives and watershed management, would be considered only where required for on-site or downstream watershed management requirements.These requirements could possibly include additional flow regulation for power-peaking purposes or yield improvements, which is a stated management objective for the Basin, under the East Slopes Policy (Alberta Government, 1984). Management efforts would likely be concentrated on the solution of land use problems or resource management conflicts only as these situations arise. On this basis, Alternative IV represents an example of 'management by crisis,' with little emphasis being placed upon long-range planning for integrated use. Therefore, this alternative would emphasize an 'ad hoc' response or reaction, rather than action taken according to plan.

Land allocations appropriate to meeting outdoor recreation and conservation objectives would be acceptable under this alternative. These allocations would likely be 'in perpetuity' and the management guidelines accompanying such allocations would tend to be inflexible. For example, allocation of lands for wilderness areas would also include the application of management guidelines outlined in the Wilderness Areas, Ecological Reserves and Natural Areas Act (1981). The potential application of watershed management programs having an impact upon these wilderness management guidelines has not been addressed in either the East Slopes Policy or Integrated Management Plan. Therefore, it is assumed by the author that this issue has been ignored in the planning process and would be dealt with on an 'as required' basis.

8.6 Description of Alternative Management Strategies

8.6.1 Overview of Alternatives

Several major resource management and land use issues are included under each alternative proposed for the Basin. These issues relate to land use, management guidelines, levels of potential development and related land allocations. It should be noted that the issues outlined by the author represent a very generalized overview of each alternative. A more comprehensive approach utilizing a much greater level of detail, would be required to develop a management plan for actual implementation in the upper North Saskatchewan Basin.

The management issues discussed under each alternative include; 1) watershed management, 2) outdoor recreation, 3) vegetation management, 4) natural resources conservation, 5) wildlife management, 6) fisheries management, and 7) land allocations and designations. In the first six issues, management strategies appropriate to the emphasis of each alternative (e.g. outdoor recreation) are outlined. Land allocations and designations appropriate to the implementation of the strategies outlined in management issues 1-6, are discussed under management issue 7. This includes a discussion of various land designations such as provincial parks, natural areas, wilderness areas, controlled buffer zones, etc. and an indication of the lands which should be held under the various designations, for each alternative. The extent of these areas may also vary under the different alternatives. Potential changes in the management guidelines associated with these land designations will also be discussed for each alternative. Many of these management issues are further sub-divided into specific subject areas, which will also be discussed for each alternative.

Resource Management and Land Use Issues

1. Watershed Management (for downstream and upstream needs).
    - a. Yield, Regime, and Water Quality
    - b. Hydro-Power Production/Reservoir Operation
    - c. Development of Additional Damsites/Structural Water Management Options.
2. Outdoor Recreation
    - a. Intensive Recreation/Facility Development
    - b. Extensive (Backcountry) Recreation
    - c. Trail Construction
    - d. Road Construction
3. Vegetation Management
    - a. Vegetation Manipulation/Timber Management
    - b. Fire Protection
4. Natural Resources Conservation
    - a. Wilderness Values
    - b. Protection of Significant Natural and Cultural Resources
5. Wildlife Management

6. Fisheries Management

7. Land Allocations and Designations

    a. Provincial Parks

    b. Natural Areas

    c. Wilderness Areas

    d. Controlled Buffer Zones

In the following analysis, management guidelines are proposed for each alternative, under each management issue and each specific subject area. This approach will permit a comparison of the guidelines required for each alternative, by specific subject area (e.g. road construction). Some of these guidelines may be the same for more than one alternative. However, under most subject areas, considerably different sets of guidelines, different types, levels or combinations of use, and different land allocations, may be described in these statements.

It should be noted that these statements are mainly examples and a much greater range of 'issues' could be considered. Issues such as A.T.V. use, commercial tourism potential, oil and gas exploration, and watershed management for yield improvement could also be used as other examples. Similarly, a much greater level of detail could be used and should be used in any actual management plan developed for the upper North Saskatchewan Basin. This could include discussion of specific issues, such as the relative importance of hydro-electric power production, in relation to the management of Abraham Lake for intensive recreational use. This level of detail is beyond the scope of this thesis.

8.6.2 Watershed Management

Alternative I (Watershed Management Emphasis)

- Yield, regime, and water quality patterns, appropriate to meeting downstream and on-site water requirements, will be maintained. Appropriate watershed management programs will be applied to maintain or where required, to improve upon existing streamflow.

- Wherever possible, watershed management activities will be integrated with other management programs such as wildlife habitat improvement, recreation facility development and wilderness conservation, to optimize potential benefits from both watershed management and secondary uses. However, watershed management will be recognized as the prime use, with all other uses being subordinate. In situations where conjunctive use is not possible or feasible, secondary uses will be traded-off to facilitate watershed management requirements.
- Operations at the Bighorn Dam and subsequent management of the Abraham Lake reservoir will be oriented towards maximizing efficiencies for power-peaking and for flow augmentation for pollution abatement downstream, in the immediate future. Recreation and other uses of Abraham Lake and related shoreline areas are acceptable, providing such use is compatible with the considerable fluctuation in reservoir level and does not conflict with dam operations or downstream water requirements. Increased flow regulation at Bighorn will be considered, where required to meet on-site or downstream management requirements. Reservoir management could eventually be oriented towards other downstream uses, such as meeting irrigation demands through inter-basin transfer.
- Development of additional damsites and other structural watershed management options will be undertaken as required, to continue to meet on-site and downstream water requirements. Such options could include the construction of works required for inter-basin transfer, and the construction of additional on-stream storage at Coral Creek, Cataract Creek and Cline River, to augment storage at Abraham Lake. Efforts will be made to ensure that wilderness, resource conservation, wildlife management, and outdoor recreation objectives are not compromised unnecessarily. However, these uses will not take precedence over the application of structural watershed management options, which may be required to meet on-site or downstream demands.
- Conjunctive use of any new storage sites will be permitted for outdoor recreation or other uses, where these can be accomodated and are compatible with the operation of these

structures.

Alternative II (Outdoor Recreation Emphasis)

- Yield, regime and water quality patterns appropriate to meeting downstream and on-site water requirements, will be maintained. Watershed management programs will be applied to maintain watershed conditions appropriate to meeting these requirements wherever possible.
- Watershed management activities will be integrated with outdoor recreation management and conservation activities, to balance these uses and obtain optimal benefits from each use. Outdoor recreation and watershed will be considered as co-dominant uses, with other uses being subordinate. Watershed management programs will be designed to have a minimal impact on recreational use (e.g. measures to minimize aesthetic impacts, encouragement of recreational use of reservoirs, etc.). Outdoor recreation programs will be developed with emphasis on compatibility with watershed management objectives and requirements (e.g. formalization of recreational use and trail upgrading, to minimize erosion and site deterioration). A high degree of integrated use would be emphasized for watershed, outdoor recreation and resource conservation, with some minimal degree of watershed benefits being traded-off to facilitate increased management for outdoor recreation and resource protection (e.g. protection of significant features and landscapes from environmental impact.).
- Reservoir storage levels at the Bighorn Dam could be modified to maintain high reservoir levels during the summer months, to improve site aesthetics and to facilitate conjunctive recreational use of the reservoir and shoreline. This may require a trade-off of some small degree of operating efficiency, with some small reduction in the level of pollution abatement downstream and some minor reduction in power-peaking capability.
- Conjunctive recreational use and facility development will be encouraged on any new storage reservoirs constructed in the Basin. Recreational use would be balanced with the

efficient operation of these structures for watershed purposes.

Alternative III (Wilderness Conservation Emphasis)

- Yield, regime and water quality patterns appropriate to meeting downstream and on-site water requirements will be maintained. Watershed management programs will be applied to maintain watershed conditions appropriate to meeting these requirements, providing that such programs do not compromise wilderness management objectives defined for the Basin.
- Watershed management activities will be integrated and balanced with wilderness management objectives, to ensure optimum benefits from these (and other) uses. Watershed and wilderness conservation will be considered as co-dominant uses, with other uses being subordinate. Other uses such as wildlife management and outdoor recreation will be facilitated, where such activities are compatible with watershed management and wilderness conservation objectives.
- Reservoir storage levels at the Bighorn Dam could be modified to maintain high reservoir levels during the summer months, to improve site aesthetics in the valley zone. Conjunctive use of the reservoir and shoreline for recreation should also be considered. Modification of reservoir storage levels to improve site aesthetics may require trading-off some watershed management benefits, in favour of site aesthetics.

Alternative IV (East Slopes Policy Emphasis)

- Yield, regime and water quality patterns appropriate to meeting downstream and on-site requirements will be maintained by land use restrictions, to ensure a high degree of watershed protection.
- Only land uses compatible with the provision of a high degree of watershed protection will be permitted.
- Reservoir operations will be optimized. Conjunctive use of the reservoir and shoreline will

only be permitted where these activities are totally compatible with reservoir operations.

8.6.3 Outdoor Recreation

8.6.3.1 Intensive Recreation/Facility Development

Different levels of facility development and different intensities of recreational use may be appropriate under each of the four alternatives. Potential guidelines for intensive recreational use and related facility development are described below. The guidelines under each alternative are intended to be appropriate under the management emphasis of each specific alternative (e.g. watershed, wilderness, etc.).

Alternative I (Watershed Management Emphasis)

- Facility development should not be permitted in areas having a low to moderate capability to sustain use, such as the Kootenay Plains and lower valley slopes.
- Facility development should not be permitted in the intermediate zone, due to the high environmental impact potential associated with the construction of access roads. Terrain conditions generally preclude the possibility of facility development in the headwaters zone (except ski area development).
- Campground and service center development will be limited to a minimal expansion of existing facilities, (Thompson Creek, Two O'Clock Creek, Cavalcade) in order to minimize the extent of watershed damage, associated with facility development. Considerable emphasis must be placed on erosion control, both during the construction phase and during facility operation.
- No facility development should be permitted within 100 m of any stream channel, in order to minimize erosion and deterioration of riparian vegetation.
- Random recreational use must be strictly controlled in the valley zone to prevent deterioration of watershed conditions. Use of developed facilities and formalized trails will be encouraged.

- All sewage from recreational facilities must have tertiary treatment prior to disposal into any stream, in cases where the nutrient or chemical loading might cause deterioration in water quality.
- Ski area development should be discouraged in the Basin, due to high potential watershed impacts, associated with site development and the construction of access roads and utility corridors.
- All facility proposals must be evaluated in terms of potential impacts on watershed conditions on-site, as well as indirect impacts in other areas of the Basin. All potential facility developments must be designed to be constructed with minimal environmental impact (e.g. facilities located away from stream channels; short, well located access roads, soil erosion control measures, etc.). Proposed developments deemed to have an unacceptable level of negative watershed impacts, must be modified to meet these guidelines.

Alternative II (Outdoor Recreation Emphasis)

- Facility development will be controlled in areas having a moderate capability to sustain use. Where such development is required, appropriate measures should be taken to minimize the extent of impacts. No facility development will be permitted in the Kootenay Plains, due to the extremely low capability of this area to sustain use.
- Campground and service center development would include expansion of the existing facilities (Thompson Creek, Two O'Clock Creek, Cavalcade). Additional facility development could occur in other areas of the valley zone. Development of auto-access camping in the intermediate zone, could also be considered in areas with a moderate to high capability to sustain development. (e.g. lower Cline Valley, Siffleur Valley). Emphasis must be placed on erosion control during and following construction, to minimize watershed impacts.
- Facility development will be encouraged adjacent to lakes and streams within the Basin, to

maximize aesthetic benefits. Appropriate watershed protection measures will be applied to minimize impacts wherever possible.

- Development of the Odyssey resort and related facilities will be encouraged, to expand the range of recreational opportunities available within the Basin.
- Random recreational use will be controlled in areas of the valley zone having a low capability to sustain use. Use of areas having a high capability to sustain use or areas modified to sustain heavy use (facility nodes) will be encouraged.
- All sewage from recreational facilities must have tertiary treatment prior to disposal into any stream, in order to prevent deterioration of water quality.
- Ski area development will be encouraged in the Sentinel Mountain/Elliot Peaks area, assuming suitable snow conditions exist and development is economically feasible. Appropriate rehabilitation measures must be applied to reduce potential watershed impacts associated with site development and the construction of related road and utility access.
- All facility development proposals must be evaluated in terms of potential impacts on watershed conditions. All facilities must be constructed with minimum environmental impact. Proposed developments deemed to have unacceptable impacts on watershed conditions must be modified, to reduce these potential impacts to an acceptable level. Projects not meeting this condition would not be permitted.

Alternative III (Wilderness Conservation Emphasis)

- Recreational facility development would be confined to the valley zone. The type and extent of development permitted, would be limited to roadside pulloffs (viewpoints), staging areas, and the maintenance of existing levels of development at Thompson Creek, Two O'Clock Creek and Cavalcade. No development will occur in the intermediate and headwaters zones.
- Recreational use will be controlled in the Basin, to minimize watershed damage and to maintain wilderness values.

- The Odyssey project will not be developed, in order to retain the wilderness character of the Basin.
- No downhill ski facilities will be developed in the Basin.
- Natural resource conservation will take precedence over recreational facility development.

Alternative IV (East Slopes Policy Emphasis)

- Recreational facility development will be confined to the portion of the valley zone (highway 11 corridor) zoned as 'general recreation,' in the East Slopes Policy. 6 Developments in this area could include additional campgrounds, services, and staging areas, to provide access to opportunities in other areas of the Basin.
- The remainder to the Basin, zoned as 'prime protection' in the East Slopes Policy, will be used for informal backcountry recreation. No facility development will be permitted in these areas.
- The Odyssey project will be developed in the small facility zone, adjacent to Abraham Lake.
- Downhill ski developments and road and utility access may be constructed in the prime protection zone (headwaters and intermediate watershed zones) since these areas would contain the only suitable terrain and snow conditions. Economic viability would be the main criteria for development. Appropriate measures would be taken during the construction phase, to limit the extent of watershed impacts.
- Sewage from recreational facilities will be disposed of in accordance with existing regulations (secondary treatment).

8.6.3.2 Extensive (Backcountry) Recreation

Different guidelines for development and management of backcountry recreational opportunities may be appropriate under each of the four alternatives. Backcountry recreation may be more or less compatible with other uses, depending upon the emphasis (e.g. watershed, wilderness, etc.) of the overall management strategy. Specific guidelines for backcountry recreation are outlined below, for each of the alternatives.

Alternative I (Watershed Management Emphasis

- Backcountry recreation (hiking and equestrian use) would be limited to areas of the Basin having a high capability to support such use. Recreational use would be limited in environmentally sensitive areas.
- Equestrian use would be limited to specific areas having the capability to sustain such use, in order to minimize soil erosion.
- Use of backcountry areas (numbers of users) will be controlled, where required to prevent watershed deterioration, due to recreational overuse.

Alternative II (Outdoor Recreation Emphasis)

- Backcountry recreation (hiking and equestrian use) will be encouraged in all areas of the Basin. Local use restrictions would be applied to control use in areas highly susceptible to disturbance.
- Equestrian use would be formalized and encouraged only in areas having a moderate to high capability to sustain such use, in order to prevent excessive soil erosion in key watershed areas.
- Backcountry use would only be controlled where use levels severely reduced the quality of recreation, or where there is unacceptable deterioration in watershed conditions. Measures such as paviing would be applied where required to increase recreational carrying capacity.

Alternative III (Wilderness Conservation Emphasis)

- Backcountry recreation will be limited where use levels detract from wilderness values or where use is sufficient to cause watershed damage.
- Equestrian use would be limited to areas of the valley zone and intermediate zone outside of Wilderness Areas or Natural Areas. Equestrian use would be formalized to minimize soil

erosion and other environmental impacts.

Alternative IV (East Slopes Policy Emphasis)

- Land use would be strongly oriented toward dispersed backcountry recreation, such as hiking, fishing, hunting, and other non-mechanized activities.
- Backcountry camping will be limited in areas having a low potential to support this activity.
- No backcountry facilities will be provided.

8.6.3.3 Trail Construction

Trail construction is required to formalize random backcountry use. Construction and upgrading of trails may serve several purposes, such as reducing erosion potential, expanding recreational opportunities, or encouraging backcountry use. However, different levels of trail development may be appropriate under different alternatives. Trail construction guidelines appropriate to each alternative are outlined below:

Alternative I (Watershed Management Emphasis)

- Existing trails would be formalized and upgraded where required to sustain use and/or reduce erosion potential.
- Existing trails in areas highly susceptible to damage and trail sections having a high erosion hazard, should be closed, reclaimed, and bypassed by properly constructed and well located trails.
- No new trails would be constructed except to replace or bypass existing trails closed and reclaimed for erosion control purposes. All new trail sections must be designed to minimize erosion. Trail locations should not create negative impacts on vegetation or wildlife range.
- Trails should be located away from streams, to minimize disturbance of riparian vegetation. The number of stream crossings must be kept to a minimum.
- Adequate drainage structures (e.g. culverts) would be required on all trails, to minimize

erosion and stream sedimentation.

Alternative II (Outdoor Recreation Emphasis)

- A network of trails would be constructed in the Basin, to expand backcountry recreation opportunities.
- Existing trails in areas highly susceptible to erosion should be upgraded or bypassed, to maintain an acceptable carrying capacity, in order to sustain recreation use.
- Adequate drainage structures (e.g. culverts) would be required on all trails, to minimize erosion and stream sedimentation.
- Trails may be located adjacent to streams or lakes, to take advantage of scenic features and to provide ease of access. Appropriate measures should be taken to minimize shoreline impacts.

Alternative III (Wilderness Conservation Emphasis)

- Existing informal trails will be retained. No trail maintenance or upgrading will be carried out in Wilderness Areas or Natural Areas. Some trail improvements in areas of the Basin outside of Wilderness Areas or Natural Areas may be considered, where essential to sustain use and ensure watershed protection.

Alternative IV (East Slopes Policy Emphasis)

- Existing trails would be retained, with local improvements made on an 'as required' basis. Such improvements could include reconstruction of trails, installation of drainage structures, etc., where required to ensure watershed protection and maintain recreational use.
- New trails will not be developed unless warranted by use levels. Construction must be completed with a minimal impact on watershed conditions.
- Trails may be constructed adjacent to streams and lakes, to increase the quality of

backcountry recreation.

8.6.3.4 Road Construction

Roads are often required in remote areas for management purposes (e.g. fire roads) and to provide access for land use. The function of roads, the extent of road networks, and the degree of conjunctive use(s) for other purposes (e.g. recreation) may vary for each alternative, depending upon the use(s) to be optimized and the degree of conflict between road development and these uses. Road construction guidelines for each alternative are described below:

Alternative I (Watershed Management Emphasis)

- Road construction should be minimized to prevent excessive damage to the watershed.
- Where roads are constructed for forest fire fighting access or watershed management purposes, conjunctive recreational use of these roads should be considered as an alternative to additional road construction.
- All roads should be constructed to minimize erosion, through proper location, extensive use of culverts, and reclamation of road right-of-ways and borrow pits, through seeding or other measures. The application of reclamation measures during the construction phase should be emphasized (e.g. watershed restoration and soil improvement programs).
- Roads must be located away from stream channels, with a minimum 200 m buffer being maintained between a roadway and any water body. The number of stream crossings must be kept to a minimum to prevent disturbance of riparian vegetation.
- Abandoned roads should be reclaimed in areas where natural revegetation is insufficient to stabilize these sites.

Alternative II (Outdoor Recreation Emphasis)

- A network of roads would be developed in the upper North Saskatchewan Basin, to improve access for recreational use, to provide access to scenic areas and significant features (e.g. Landslide Lake, Coral Creek Canyon) and to facilitate auto touring.

- Service roads will be constructed for management purposes as required (e.g. fire roads, forestry roads, etc.).
- Conjunctive recreational use of some service roads would be considered where conflicts with management operations were minimal. Development of limited all-terrain vehicle roads could be considered in some areas of the valley and intermediate zone, but would be restricted to areas having a high capability to sustain this type of use.
- Roads could be located adjacent to streams or lakes, to improve site aesthetics for recreational motorists. Appropriate measures would be taken to minimize shoreline impacts, in order to minimize soil erosion and subsequent stream sedimentation.
- All roads should be constructed to minimize erosion, through proper location, extensive use of culverts, and reclamation or road right-of-ways and borrow pits through seeding. The application of reclamation measures during the construction phase should be emphasized.
- Abandoned roads should be reclaimed in areas where natural revegetation is insufficient to stabilize these sites.

Alternative III (Wilderness Conservation Emphasis)

- Road construction will not be permitted in the headwaters and intermediate zones, in order to maintain wilderness values and prevent watershed damage.
- Expansion of the existing road network in the valley zone should not be considered.
- Existing roads should be upgraded where required to minimize soil erosion.
- Abandoned roads should normally be reclaimed through natural revegetation. In situations where a high erosion hazard exists, watershed restoration and soil improvement programs could be considered.

Alternative IV (East Slopes Policy Emphasis)

- New road development will be confined to the valley zone. Emphasis would be placed on constructing roads to provide access to recreational facilities. New road development would only be considered in the intermediate and headwaters zones, where necessary to provide access to downhill ski facilities.

- Service roads would be constructed where required for management purposes. Recreational use of service roads (vehicle access) would not be considered. No public all-terrain vehicle roads would be constructed.
- All roads would be developed under guidelines designed to minimize environmental impacts and soil erosion. This would include proper road location, extensive use of culverts, and reclamation of road right-of-ways and borrow pits.
- Existing roads would be upgraded to support increased recreational use where required.
- Abandoned roads would be reclaimed either through natural revegetation or through the application of watershed restoration and soil improvement programs.

8.6.4 Vegetation Management

8.6.4.1 Vegetation Manipulation/Stand Management

Vegetation manipulation/stand management programs may be applied for many purposes, such as improving forest stands for increased timber yields or to maintain acceptable watershed regime patterns. These programs may also be used to improve site aesthetics for recreational use, or to enhance wildlife habitat. Different degrees of management may be required for each of the alternatives, based upon specific requirements. For example, for watershed improvement purposes, programs oriented toward disease and infestation control may be appropriate. Under a wilderness preservation alternative emphasizing natural processes, natural deterioration in forest conditions may be stressed. Management guidelines appropriate to each of the alternatives are outlined below:

Alternative I (Watershed Management Emphasis)

- Vegetation management programs (sanitation cutting, selective thinning, infestation control) will be applied where required to maintain healthy, mature forest cover, in any area of the upper North Saskatcehwan Basin. This could include small scale timber harvesting to maintain stand age and species diversity for watershed improvement purposes, in overmature stands. Application of such measures would require changes to the existing Wilderness Areas legislation, which prohibits environmental modification by man. Application of these methods on lands designated as Provincial Parks, should be an acceptable resource management practice, providing conflicts with outdoor recreation and conservation objectives can be minimized.

- Watershed rehabilitation programs involving tree planting, seeding or other such measures will be applied where required to stabilize soils and reduce erosion. Fertilization, pesticide application and other measures could also be considered to enhance plant growth, provided these measures do not have any effects on wildlife or water quality, either within the study area or in areas downstream.

Alternative II (Outdoor Recreation Emphasis)

- Vegetation management programs (sanitation cutting, selective thinning, etc.) will be applied where required to maintain healthy, mature forest cover. These measures would also be applied to reduce hazards to recreational use (e.g. dead fall). Application of vegetation management programs would have a lower priority within established Wilderness Areas.
- Vegetation management programs must be designed to be accomplished with minimal aesthetic impacts, in order to maintain the scenic qualities of the upper North Saskatchewan Basin for recreational use.
- Watershed rehabilitation programs involving tree planting, seeding or other such measures may be applied to stabilize soils and reduce erosion where required. These measures should also be used extensively, to restore areas of the Basin damaged by recreational overuse, or to improve the carrying-capacity for recreation on a local basis. Watershed rehabilitation

programs would not be applied in established Wilderness Areas, unless absolutely required for watershed protection purposes.

Alternative III (Wilderness Conservation Emphasis)

- Vegetation management programs (sanitation cutting, selective thinning, etc.) will not normally be applied in established Wilderness Areas and will be limited to situations where such measures are urgently required for watershed management purposes in other areas of the Basin. Sanitation cutting may only be considered where there is a proven hazard to merchantable timber outside of the study area.
- Watershed rehabilitation programs involving tree planting, seeding or other such measures will not normally be considered. Natural revegetation will be emphasized in order to maintain natural processes wherever possible. Where deemed essential for meeting defined watershed management objectives, these programs could be considered as a last resort, in established Wilderness Areas.

Alternative IV (East Slopes Policy Emphasis)

- Vegetation management emphasis will be on the maintenance of the natural environment. However, management programs may be applied for watershed improvement or to improve site aesthetics to enhance recreational potential. Greater emphasis would be placed on vegetation management in the general recreation zone than in the prime protection zone.
- In the prime protection zone, sanitation cutting and other management programs will be permitted only where there is a proven hazard to merchantable timber outside of this zone. Vegetation management programs would not normally be applied within established Wilderness Areas, due to the potential conflict with wilderness management objectives.

8.6.4.2 Fire Management and Suppression

Fire detection and suppression programs are applied in all forested areas to minimize the loss of productive timber as well as for secondary benefits of watershed protection, public safety, and protection of fish and wildlife. However, fire is a natural phenomenon which is important for ensuring forest succession. Fire may also be used as a management tool for simulating natural succession in overmature stands (the result of intensive fire protection) and prescribed burns may be appropriate under certain forest management philosophies. The emphasis placed upon fire protection and the degree of emphasis placed on fire as a management tool may vary, depending upon the objectives to be maximized. This emphasis is also somewhat different in each of the alternatives described in this chapter. The different degrees of emphasis on fire suppression and prescribed burning appropriate under each alternative, are outlined below:

Alternative I (Watershed Management Emphasis)

- Existing levels of fire detection and suppression would be maintained, with action taken on all fires to ensure a high degree of watershed protection. Fire detection and suppression capability would be increased where required, to compensate for increased recreational use and subsequent increases in the potential for fires.
- Controlled burning may be considered as one method for simulating forest succession to maintain healthy forest stands. Application of such programs would only be considered in overmature stands and must be confined to very small areas, to prevent extensive watershed damage and stream sedimentation problems. Sanitation cutting would be the preferred method because it is less hazardous than prescribed burning.

Alternative II (Outdoor Recreation Emphasis)

- Fire detection and suppression capability would be increased in response to increased fire potential and public safety risks, resulting from facility development and increased recreational use. Action would be taken on all fires to provide for adequate levels of watershed protection and to ensure public safety.
- Controlled burning may be considered in order to simulate natural forest succession or to

reduce fire fuel loads in grassland areas used extensively for recreation, such as areas adjacent to the David Thompson Highway. Application of such programs would normally be limited to overmature stands and grassland areas with a high fire potential, such as areas outside the Kootenay Plains Natural Area.

- Prescribed burns would not be permitted within established Wilderness Areas or within the Kootenay Plains Natural Area.

Alternative III (Wilderness Conservation Emphasis)

- Fire detection and suppression capability would be maintained at existing levels. No action would be taken on fires within the Wilderness Areas, unless these were large enough to spread into other areas of the Basin or were large enough to have a significant impact upon watershed conditions. Action would not be taken on fires smaller than 4 hectares in other areas of the Basin, except in the valley zone. Action would be taken on all fires within the valley zone, due to the potential for damage to recreational facilities in the valley and considerable erosion potential resulting from destruction of the marginal grasslands in the Kootenay Plains Natural Area.
- Forest succession would be accomplished by natural means. Prescribed burns would not be used in the Wilderness Areas or Natural Area. Prescribed burns could be considered as a management option in other areas of the Basin, but only where absolutely necessary for watershed management purposes.

Alternative IV (East Slopes Policy Emphasis)

- Fire detection and suppression capability would be maintained at existing levels. Fire suppression would only be considered where there was a proven hazard to mechantable timber outside of the prime protection zone (Alberta Government, 1984). Action would be taken on all fires within the general recreation zone, to ensure public safety and to protect the capital investment in recreation facilities.

- Prescribed burns would be considered in all areas of the Basin except in established Wilderness Areas and the Kootenay Plains Natural Area. Prescribed burns could be applied to simulate natural forest succession for watershed improvement, or to improve upon wildlife habitat.

8.6.5 Natural Resource Conservation

Natural resource conservation is an important objective under all alternatives. The degree to which conservation objectives are compatible with other uses may vary, depending upon the emphasis of each alternative (e.g. watershed, wilderness, etc.). Therefore, somewhat different degrees of emphasis on the extent of natural resource conservation, may be appropriate under each alternative. Different degrees of compromise between natural resource conservation and resource use, under each alternative, are described in this section.

Alternative I (Watershed Management Emphasis)

- Wilderness values will be protected in the headwaters and intermediate watershed zones, by limiting land use activity to low levels of backcountry recreation, in the short to medium term. Where considered essential for watershed management purposes, management programs such as infestation controls, selective thinning, sanitation cutting and snow pack management would be applied in situations where no other practical alternatives exist. Wilderness values will not be traded-off for any other land use except watershed management.
- Significant natural and cultural features will be protected in the upper North Saskatchewan Basin. Access may be provided to such features for interpretive or recreational purposes, providing this does not conflict with watershed management requirements or result in any significant watershed damages.
- Wilderness values and the protection of significant natural and cultural features will be given adequate consideration in any water resource projects proposed for the upper North

Saskatchewan Basin. Options having a minimal impact upon wilderness values or significant natural and cultural features will be preferred, however where no compromises are possible, watershed will take precedence over natural resources conservation.

Alternative II (Outdoor Recreation Emphasis)

- Wilderness values will be protected within established Wilderness Areas. In other areas of the headwaters and intermediate watershed zones, maintenance of wilderness values will be balanced with recreational use and potential facility development. Management programs for watershed improvement such as snow pack management or sanitation cutting will be applied where required, but must not have significant negative impacts upon recreational use or site aesthetics. In areas outside of the established Wilderness Areas, wilderness values may be traded-off to facilitate outdoor recreation or watershed improvement programs.
- Significant natural and cultural features will be protected in the upper North Saskatchewan Basin. Where appropriate, access will be provided to such features for interpretive or recreational purposes.
- Wilderness values and the protection of signficant natural and cultural features will be given adequate consideration in relation to potential impacts of recreational overuse and impacts of potential watershed management activities. Significant natural or cultural features will not be traded-off to facilitate increased recreational use. Significant natural and cultural features will not be traded-off to facilitate the application of watershed management programs or water resource developments, unless no other alternatives are possible and this cost can be justified in relation to watershed benefits.

Alternative III (Wilderness Conservation Emphasis)

- Wilderness values will be protected within established Wilderness Areas and within all other areas of the headwaters and intermediate watershed zones. Watershed management programs emphasizing vegetation removal will not be applied within established Wilderness Areas and will be limited in other areas of the headwaters and intermediate watershed zones. Some degree of watershed benefits would be traded off to provide for a high level of protection, to maintain wilderness values (e.g. negligible impact of man on the environment).

- Significant natural and cultural features will be protected in the upper North Saskatchewan Basin. Access to such features outside of the valley zone, will be restricted to trail access only. Access to features will be limited where considered essential for resource protection purposes.
- Wilderness values and the protection of significant natural and cultural features will be given adequate consideration, in relation to watershed management and recreational use requirements. Significant natural or cultural features will not be traded-off to facilitate increased recreational use. Watershed management programs, including water resource projects such as dams or diversions, will not compromise the protection of significant natural and cultural features.

Alternative IV (East Slopes Policy Emphasis)

- Wilderness values and watershed conditions will be protected by land use restrictions, with dispersed, backcountry recreation being the only acceptable land use. Management programs for watershed protection, such as sanitation cutting and selective thinning will not be considered, unless there is a proven hazard to merchantable timber outside of the East Slopes prime protection zone (headwaters, intermediate and upper valley watershed zones). Protection vs. development issues will be resolved as these arise.
- Significant natural and cultural features will be protected in the upper North Saskatchewan Basin. Where considered appropriate, access will be provided to selected features for interpretive or recreational purposes. Road access will only be provided in the general recreation portion of the valley watershed zone. Trail access would be considered in all

other areas of the upper North Saskatchewan Basin.

- Wilderness values and the protection of significant natural and cultural features will be given detailed consideration in any evaluation of recreational over-use or assessment of watershed management requirements.

8.6.6 Wildlife Management

Different wildlife management guidelines, especially for ungulate range improvement or population control, may be appropriate under different management strategies. For example, under a strategy oriented towards yield improvements and complementary development of additional rangeland, increases in ungulate populations would be appropriate. However, this would be in conflict with a strategy oriented toward regime improvement and erosion control. Management guidelines appropriate to each alternative strategy are described below:

Alternative I (Watershed Management Emphasis)

- Wildlife management programs may be applied to control ungulate populations (deer and elk) within the Basin, to reduce potential impacts of overbrowsing and overgrazing on watershed conditions. Ideally, ungulate populations would be maintained at a level somewhat lower than the rated capacity of the Basin to sustain this use.
- Range improvement programs such as timber removal in heavily forested areas will not normally be considered, unless such programs are also beneficial for watershed management purposes.
- Hunting may provide the most effective method of controlling ungulate numbers and will be permitted in the Basin, except on lands designated as wilderness areas, natural areas or provincial parks. Management hunting may be considered in provincial parks and natural areas, where overpopulation problems exist (e.g. overbrowsing).

Alternative II (Outdoor Recreation Emphasis)

- Wildlife management programs may be applied to control ungulate populations where it is proven that overbrowsing and overgrazing has a significant impact on watershed conditions. However, application of such programs must be balanced by consideration of the aesthetic and recreational benefits of maintaining existing ungulate population levels.
- Range improvement programs may be considered where there is a requirement to sustain a given population level and there are no significant conflicts with watershed management.
- Recreational hunting will be permitted in areas of the Basin outside of wilderness areas, natural areas, or provincial parks.

Alternative III (Wilderness Conservation Emphasis)

- Wildlife management programs will not be applied in the Basin, except as a last resort for wildlife conservation or watershed protection purposes. Natural processes and population cycles will be relied upon to maintain an appropriate balance in ungulate populations and numbers of predators.
- Wildlife habitat improvement programs will not be carried out, as environmental manipulation is in conflict with the philosophy of wilderness management applied in Alberta.
- Hunting will be strictly controlled within the Basin.

Alternative IV (East Slopes Policy Emphasis)

- Wildlife management programs may be applied in the Basin to maintain or improve populations.
- Range improvement or management programs may be applied as required. All programs will be coordinated with other land use activities such as timber harvesting. Compatible uses will generally include dispersed recreation and limited timber harvesting.
- Hunting will be controlled in the general recreation zone portion of the Basin (valley

zone). Hunting will be permitted in all other areas of the Basin, except where prohibited by land designation (e.g. on lands designated as wilderness areas, natural areas or provincial parks).

8.6.7 Fisheries Management

Fisheries management includes any programs undertaken to improve stream conditions for improved fish productivity. In many cases, this could involve pollution abatement and erosion control or other land use limitations as well as fish stocking programs. Fisheries improvement programs are generally compatible with many different land management strategies. However, the purpose and intensity of fisheries management programs applied and the importance of such programs in relation to other uses, may vary under the different alternatives.

Alternative I (Watershed Management Emphasis)

- Fisheries may be managed for habitat or water quality improvement, where required to enhance fishery potential or to prevent deterioration of stream or lake conditions. Improvement of fisheries both upstream and downstream could be considered as a secondary benefit of watershed management programs oriented toward water quality improvement.

Alternative II (Outdoor Recreation Emphasis)

- Fisheries management programs will be used to improve fish habitat, in order to maintain a viable sport fishery within the Basin.

Alternative III (Wilderness Conservation Emphasis)

- Existing stream habitat will be maintained by minimizing land use impacts adjacent to streams and preventing stream pollution. No active fisheries management programs will be implemented.

Alternative IV (East Slopes Policy Emphasis)

- Low intensity fisheries improvement programs may be applied in areas zoned as 'general recreation' (lower portion of the valley watershed zone). Fisheries management programs may be considered in the portion of the study area zoned as 'prime protection,' only where necessary to prevent the loss of existing fisheries. No fisheries management programs may be considered in established Wilderness Areas.

8.6.8 Land Allocations and Designations

Different land allocations and designations and differences in the extent of these areas, may be appropriate under each of the four alternatives. Similarly, different levels of development and different management strategies might also be appropriate in these areas, under different alternatives. Potential land designations and complementary management guidelines are suggested below, which could be appropriate to the management emphasis of each alternative. Four designations are considered; provincial parks, natural areas, wilderness areas and controlled buffer zones.

Alternative I (Watershed Management Emphasis)

Provincial Parks

There are two possible park development options which could be appropriate under this alternative.

- A series of small recreation areas could be established in the valley zone, to provide accomodation and to support backcountry use. These sites could be established as provincial recreation areas, for the purpose of providing for outdoor recreation, rather than conservation. Under this option, other lands (excluding the Kootenay Plains Natural Area and Wilderness Areas), could be managed for watershed, backcountry recreation, wildlife and other uses, under a 'multiple' use approach, with watershed being the dominant use.

- A provincial park could be established over the entire upper North Saskatchewan Basin, to provide accommodation and manage backcountry use. A much greater emphasis would be placed upon conservation and the protection of significant natural and cultural features under this option. Facility development could be approximately the same as in option 1 or could occur at a somewhat lower level. However, in order to manage the basin for watershed, considerable changes in park management philosophies, policies and strategies could be required. This option would only be viable if all necessary watershed management requirements could be met under this designation. This could require some changes to the existing legislation, to ensure that vegetation treatment, snow pack management, construction of additional storage, and limitation of recreational use or ungulate populations could be accomplished within this park.

Natural Area

The Kootenay Plains Natural Area would remain at its present size and would continue to be highly protected. Recreational and other uses of this sensitive area would be controlled, to minimize erosion, as this would be essential to the maintenance of existing watershed conditions. Some additional flooding of the extreme eastern edge of the Kootenay Plains might also occur as the result of increased flow regulation at Bighorn. This may necessitate some small reductions in the size of the Natural Area in the future.

Wilderness Areas

The Siffleur and White Goat Wilderness Areas currently provide for the protection of a large area of the Basin from development. This 'protected' status helps to ensure a high level of watershed protection. However, a change in existing regulations would be required, in order to provide a high level of fire protection and to permit application of infestation control and vegetation management programs, as well as other improvements which might be required for watershed management purposes. This should not compromise wilderness values to any great extent. Some reduction in the size of the White Goat Wilderness could also be required to facilitate the construction of additional storage, but this development would likely occur only in areas already deleted from Wilderness Area status.

Controlled Buffer Zones

The Cline sub-basin would not be considered for controlled buffer zone status, as this would limit future damsite development opportunities. The Cline sub-basin should continue to be managed as public land, with adequate guidelines applied to ensure the protection of watershed conditions.

The Whiterabbit sub-basin could be considered for controlled buffer zone status, to provide additional protection for the Siffleur Wilderness Area. This would not conflict with watershed management, as no potential damsites exist in this sub-basin. However, changes to the legislation would be required to permit the application of watershed management programs, such as vegetation management.

Alternative II (Outdoor Recreation Emphasis)

Provincial Parks

There are also two options for provincial park development under this alternative.

1. Develop a provincial park in the valley zone adjacent to the Kootenay Plains Natural Area (roughly corresponding to the general recreation zone identified in the East Slopes Policy), covering approximately 20,000 hectares. This area would be managed essentially for outdoor recreation and conservation objectives, with guidelines being applied to protect watershed conditions. This park could be intensively developed, with service centers, large auto-access campgrounds and other facilities. The park would also serve as a staging area

for backcountry use, which would be encouraged in the Basin. Additional recreation areas could also be developed on the Abraham Lake shoreline and adjacent to any recreational roads constructed outside of the valley zone. Remaining lands in the upper North Saskatchewan Basin (outside of the Kootenay Plains and Wilderness Areas) would be designated as public lands and managed for 'multiple-use', with watershed and outdoor recreation being the dominant uses. This designation would ensure that some existing forms of recreation such as hunting, could continue. This would also permit conjunctive management of lands for watershed purposes, without major conflicts with park management objectives.

2. Develop a provincial park over the entire upper North Saskatchewan Basin, (excluding the Wilderness Areas and Kootenay Plains), covering approximately 82,000 hectares. This park would have essentially the same facility development as outlined under option 1, but recreation activities would be more actively managed. Some activities, such as hunting, could be precluded by existing park policies. Wilderness values and significant natural and cultural resources might be afforded a greater degree of protection under this option. However, existing regulations would have to be changed, as described under Alternative II, to permit conjunctive management for watershed purposes.

Natural Area

The Kootenay Plains Natural Area would remain at its present size and would continue to be highly protected. Recreational use would be controlled where this use is sufficient to compromise watershed conditions. Some measures such as trail paving could be used to improve the recreational carrying-capacity of the area. However, these measures may be in conflict with the management guidelines for natural areas.

Wilderness Areas

The Siffleur and White Goat Wilderness Areas would remain at their existing size. However, changes in existing regulations would be required in order to meet outdoor recreation and watershed management objectives. The changes in legislation, outlined under Alternative I, would also be required under this alternative, to provide for watershed management. Philosophical and legislative changes may also be required in order to permit increased use for backcountry recreation, in a wilderness setting.

Controlled Buffer Zones

The Cline sub-basin (adjacent to the White Goat Wilderness) would not be designated as a controlled buffer zone, as this would limit water resource development opportunities and would also limit future construction of access roads and utility corridors, should a ski area be approved for development in the Mt. Cline - Elliot Peaks area. Informal recreation, such as trail riding and hunting would be continued in this area as an interim use, pending water resource development. This use would also be managed to minimize negative impacts on watershed conditions.

The Whiterabbit sub-basin could be considered for controlled buffer zone status, providing the necessary changes to the regulations could be made, to permit watershed management and increased recreational use. Alternative designations might include provincial recreation area, or developing a new designation which would provide the necessary management requirements and protection from development. These land designations would not conflict with watershed management at present, due to the absence of potential damsites in this sub-basin.

Alternative III (Wilderness Conservation Emphasis)

Provincial Parks

A provincial park, covering the entire upper North Saskatchewan Basin (excluding Wilderness Areas and the Kootenay Plains), would be appropriate under this alternative, to provide for a high degree of resource protection. Facility development would be limited to the Highway 11 corridor, with other areas of the park being used for appropriate backcountry activities. Establishment of this park would provide a considerable buffer around the two Wilderness Areas, as well as provide for better protection for the Kootenay Plains.

Natural Area

The Kootenay Plains Natural Area would be expanded to include significant 'prairie' features east of Abraham Lake and west of Highway 11, south of the Cavalcade Group Campground. The Natural Area would continue to be highly protected.

Wilderness Areas

The White Goat Wilderness Area would be expanded to its pre-1973 size, with the addition of most of the Cline sub-basin. This would provide for greater protection of wilderness values within the Basin. The Siffleur Wilderness would remain at its present size. Wilderness management programs (and regulations) would require modification to permit some watershed management programs, such as fire protection and vegetation management. Some changes could also be required to permit equestrian use in the Cline sub-basin, under Wilderness Area status.

Controlled Buffer Zone

The Whiterabbit sub-basin could be designated as a controlled buffer zone as outlined under Alternative I and II.

Alternative IV (East Slopes Policy Emphasis)

Provincial Parks

The establishment of a provincial park corresponding to the general recreation zone would be appropriate under this alternative. This would be managed and developed to approximately the same level outlined under option 1 in Alternative II. The remainder of the Basin would be managed for 'multiple' uses such as backcountry recreation, wildlife, and watershed protection, in a manner appropriate to the 'prime protection' guidelines under the East Slopes Policy (Alberta Energy and Natural Resource, 1980; Alberta Government, 1977).

Natural Area

The Kootenay Plains Natural Area could be expanded, as described under Alternative III, to protect additional significant areas.

Wilderness Areas

Wilderness Areas would be maintained at existing levels and would be managed in accordance with the Wilderness Areas, Ecological Reserves and Natural Areas Act and within the management guidelines for the prime protection zone, as outlined in the East Slopes Policy.

Controlled Buffer Zone

The Cline sub-basin would not be considered for designation as a controlled buffer zone, in order to leave this area open for potential damsite development and to allow for existing recreational use, such as hunting and trail rides. This area would be managed in accordance with guidelines for the prime protection zone.

The Whiterabbit sub-basin could be designated as a controlled buffer zone, in order to further protect the Siffleur Wilderness, by preventing industrial or resource development, while permitting recreational activities, such as hunting, fishing and equestrian use.

8.7 Implications of Alternative Management Strategies

8.7.1 Assessing the Implications

Implementation of any of the alternative management strategies outlined in this chapter, would require some changes in the management philosophies, policies, and strategies currently applied in the upper North Saskatchewan Basin. The extent of these potential changes would vary under each alternative. There are also different land designation and land management options possible, within each of the alternatives proposed. For example, establishing a provincial park over the entire study area may be one land designation option, appropriate for meeting the outdoor recreation objectives defined for the Basin. Alternatively, the establishment of a series of small recreation areas may also satisfy these same objectives. Changes to the existing management philosophies, policies and strategies, applied to designated lands (e.g. management guidelines applied within a wilderness area) are also required under some alternatives. For example, a change in wilderness management philosophy from the traditional, biocentric approach, in which the protection of the environment from modification by man is stressed, to an integrated use or anthropocentric philosophy, which emphasizes active management of 'wilderness' to improve wildlife habitat, recreation opportunities or watershed conditions, may be required under some alternatives (Hendee, Stankey, and Lucas, 1978). The potential requirements for change in the existing philosophies, policies and guidelines, and the implications of these changes will be assessed for each alternative.

Priorization of land uses is also implied in each alternative. Land uses identified for the upper North Saskatchewan Basin in these alternatives, may be either dominant, co-dominant, secondary, co-secondary, tertiary, conjunctive, or interim (Laycock, 1962, 1957). Combinations of these land use categories are also possible (e.g. interim, secondary use). In each alternative, the relative priority of the various land uses may be different, depending upon the management emphasis. For example, wilderness conservation and watershed would be co-dominant uses under Alternative III (Wilderness Conservation Emphasis).

Dominant or 'prime' use implies the highest priority for use (Laycock, 1962, 1957; Wilm and Dunford, 1941). Co-dominant use implies that two uses will have equal value and the highest priority will be placed on these uses. All other land uses will be considered to be subordinate to these uses. Secondary uses are of subordinate importance relative to dominant uses and will generally only be considered where these can be accomodated without detracting from the dominant use(s). Co-secondary implies more than one land use in this subordinate position. Co-secondary uses will be of equal value, but all these uses will remain subordinate to all dominant uses. Specific land allocations may be made to facilitate secondary uses(s), however the management of these lands must not compromise the objectives defined for the dominant use(s).

Tertiary land uses have a relatively low priority and are subordinate to all dominant and secondary uses. Specific land allocations for tertiary uses would not be considered and these uses would have to be facilitated on lands managed for both dominant and secondary uses. Tertiary uses would have to be accomplished within the limitations imposed by all dominant and secondary uses within the Basin.

The term conjunctive use implies that a land unit is being managed to sustain a number of dominant, secondary, and possibly tertiary land uses, at the same time (Laycock, 1957a). For example, an area managed for watershed, with allowances made for secondary uses such as outdoor recreation and timber harvesting and tertiary uses such as wildlife and fisheries, would be an example of a conjunctive use situation. Interim use implies a land use of dominant, secondary or tertiary priority, applied in lieu of another land use, until some future development occurs (Laycock, 1957a). For example, recreational use of a stream for a period of years prior to the construction of on-site storage, would be considered as an interim use, in a long-range management plan. Interim uses may also become permanent uses in situations where the future developments or changes in land allocations do not materialize. This could occur in situations where two sites are reserved for future damsites, but only one site is developed.

8.7.2 Alternative I (Watershed Management Emphasis)

Selection of Alternative I would result in greater emphasis being placed upon active watershed management to improve upon existing stream regime and water quality. Management policies and strategies would also emphasize the future prospects for additional storage and interbasin transfer. This represents a fundamental change from the current emphasis placed on providing a high degree of watershed protection, as considerable environmental modification could be required. The emphasis placed on watershed management would result in somewhat less emphasis being placed upon outdoor recreation, wilderness, wildlife and natural and cultural resource conservation. Under this alternative, watershed would be recognized as the dominant use of the upper North Saskatchewan Basin, with all other uses being of subordinate importance. Outdoor recreation, wilderness, and natural and cultural resource conservation would be considered as co-secondary uses. Wildlife and fisheries would be considered to be tertiary uses.

Land designations and management guidelines would require a high degree of flexibility, to permit the eventual development of additional on-stream storage, diversion works, or the application of appropriate vegetation management programs. Provisions could also be made for wilderness, outdoor recreation, the conservation of natural and cultural features, and wildlife, where these objectives can be accomplished with minimal implications for watershed management.

Some conflicts would likely occur between watershed management and the existing emphasis placed on outdoor recreation and conservation objectives. For example, management conflicts could occur between active management programs for watershed improvement, such as vegetation manipulation or increased flow regulation, and with the protection of lands to meet wilderness objectives. However, many potential conflicts could be resolved through proper land use planning. This could be partially accomplished by inventorying potential damsites and diversion routes for interbasin transfer, and identifying the watershed conditions required to meet the watershed management objectives defined for the Basin. Potential watershed management requirements could be established on this basis. Specific allocations of lands to watershed uses would only be required at these potential development sites, but such allocations would not necessarily imply exclusive use for water resource development. Outdoor recreation could be managed and encouraged as an interim use of these sites. Outdoor recreation could continue to be a conjunctive use of these sites following development, providing that there are no significant conflicts with watershed management programs. In other areas of the upper North Saskatchewan Basin, efforts would be made to integrate watershed management activities with secondary and tertiary uses, in order to ensure multiple-use benefits wherever possible.

Watershed management requirements could be realized under several different land designations, providing that some changes were made in existing management policies and strategies applied within these areas. For example, if the entire upper North Saskatchewan Basin (excluding the Wilderness Areas) were designated as a provincial park, watershed requirements could not be met under existing policies and strategies. However, the existing provincial park zoning framework could be revised to include additional zones, such as a 'water resource development zone', which could correspond to potential damsites and water diversion routes. The dominance of water resource development, interim recreation management and post development recreational use could be recognized in the management guidelines developed for this zone. A 'watershed management forest' zone could also be added, which would be managed for watershed objectives as well as outdoor recreation and conservation objectives. This zone could correspond to forest areas having a moderate to high potential for improvement through management or maintenance through appropriate protection (e.g. fire and infestation controls). Guidelines could also be applied to minimize the impacts of recreation overuse in this zone. Alternatively, the zoning guidelines accompanying the existing park zones such as facility, general outdoor recreation, primitive, etc. could be changed, to recognize the management requirements for the maintenance or improvement of watershed conditions. These changes would ensure adequate recognition of the potential for conflicts between watershed management and park management and would serve to minimize such conflicts in the long-term. For example, selective thinning, sanitation cutting, snow pack management and other such programs would not conflict with park management, if the philosophy of park management were changed, especially since these activities may also enhance environmental conditions. This may be partially resolved by a better definition of park management objectives relative to actual outdoor recreation and natural resource conservation requirements. For example, does selective thinning for stand improvement really compromise the protection of provincially significant landscapes? On this basis, redefining objectives might improve resource use benefits from both a watershed management and park management perspective. This type of compromise could be required to provide for integrated use under a watershed management alternative, in order to minimize limitations for both secondary and tertiary uses.

Similarly, wilderness management philosophies, policies and guidelines would also require modification under this alternative. Although construction of additional damsites and diversion works may be in direct conflict with the biocentric concept of wilderness, traditionally applied in Alberta, this could be minimized by removing potential damsites from Wilderness Area status. Although this may cause some short-term conflicts and public opposition, it would serve to minimize or perhaps eliminate serious conflicts in the medium to long-term. Vegetation management programs could eventually be required to improve upon watershed conditions. Fire suppression and other forest protection measures would be required at present and must be continued to at least maintain existing watershed conditions. Application of these programs may be in conflict with the biocentric concept of wilderness, but this could be overcome by adopting an anthropocentric philosophy, which would emphasize a greater degree of active wilderness management for 'multiple-uses' such as wildlife, outdoor recreation and watershed (e.g. simulating or modifying natural processes). Under such a philosophy, management programs such as fire control, selective thinning and infestation controls would be acceptable and since these are required for watershed management, watershed and wilderness conservation could become more compatible uses. These changes in existing management philosophies, policies and guidelines would be required to optimize long-term on-site and downstream watershed benefits, but many outdoor recreation and wilderness objectives could also be met in the long-term. However, selection of Alternative I would imply that some of the existing emphasis on outdoor recreation and conservation would be traded-off to facilitate increased benefits from watershed management. However, the loss of these outdoor recreation and conservation benefits could be minimized, through proper land use planning. Increased management for watershed would also be appropriate under the goals defined for the East Slopes Region in the East Slopes Policy. This degree of emphasis upon management would certainly be appropriate, since "the highest priority is placed on watershed management to ensure a reliable supply of clean water for aquatic habitat and downstream users." (Alberta Government, 1977).

8.7.3 Alternative II (Outdoor Recreation Emphasis)

Selection of Alternative II would result in greater emphasis being placed upon outdoor recreation, especially upon facility oriented or frontcountry activities, such as auto-access camping and auto-touring. This could include the provision of improved access to high quality recreational resources and expansion of recreational opportunities into areas now used only for informal, backcountry activities. Watershed management would also be an important use of the Basin and would be highly integrated with outdoor recreation, to optimize both uses. On this basis, watershed and outdoor recreation would be considered as co-dominant uses under this alternative. Wilderness conservation and the protection of significant natural and cultural resources would be secondary uses. Wildlife and fisheries would be considered as tertiary uses.

Expansion of outdoor recreation facilities and opportunities into lands outside the Highway 11 corridor (into the upper valley and intermediate watershed zones) could result in increased environmental impact and increased emphasis on management to maintain recreational carrying capacity. This would be achieved at the cost of some reduction in wilderness values and resource conservation, with greater use being made of the available resources in the short to medium term. Watershed management for on-site and downstream uses, may also result in a further reduction in wilderness values and less protection of significant natural and cultural features.

Potential conflicts between the dominant uses (outdoor recreation and watershed) and the secondary uses (wilderness and the protection of significant natural and cultural features) could be partially resolved by modifying management philosophies, policies and strategies associated with the secondary uses. The same changes to provincial park and wilderness area management philosophies, policies and strategies, as described under Alternative I, could also be required under this alternative.

In order to ensure that outdoor recreation is given equal weighting with watershed management, some degree of watershed management may have to be traded-off, in order to facilitate conjunctive recreational use. On this basis, less emphasis would be placed on watershed management under this alternative than in Alternative I. The resolution of conflicts between these co-dominant uses would therefore require some changes to the existing philosophies, policies, and strategies governing these uses. For example, the recreational use of reservoirs and active management of reservoirs for recreation, in addition to management for flow regulation, hydro-power production or irrigation storage, has not been encouraged in Alberta. This would be particularly true of situations which require changes in reservoir operation (flow releases), to improve recreational opportunities, at the expense of small reductions in operational efficiency, relative to power-peaking capability or optimum flow releases. However, potential conflicts between watershed and outdoor recreation could be minimized in the long-term, through detailed land use planning and by balancing watershed management and outdoor recreation objectives.

Special measures could also be required, to minimize the impact of recreational use on watershed conditions. For example, management programs to limit backcountry use could be required to protect the watershed from impacts of recreational overuse, as well as to ensure that a high quality recreational experience can be provided. On this basis, some outdoor recreation management programs and watershed management programs could be highly compatible.

Wilderness conservation and the protection of significant natural and cultural resources could continue to be recognized as important secondary land uses which would be encouraged, wherever these can be accomodated without compromising the dominant uses. In many cases, these uses could be made compatible with the dominant uses or could be modified to be compatible, without any major compromises. For example, wilderness values, site aesthetics and protection of significant natural and cultural features are important for backcountry recreation. Maintenance of these qualities would be essential to maintaining a high quality recreational environment. Therefore, conjunctive management for wilderness conservation often enhances recreational use of an area.

Tertiary uses such as wildlife and fisheries may also be highly compatible with both watershed and outdoor recreation uses and may also be compatible with wilderness and park management objectives. For example, wildlife habitat may be improved by some watershed vegetation management programs. Some programs, such as selective thinning, may enhance recreation potential by increasing wildlife viewing opportunities. Fisheries management programs, such as stocking streams, may also enhance the recreational potential, as well as improve water quality. Although such programs would conflict with the biocentric philosophy of wilderness management, such programs could be compatible with the anthropocentric philosophy. Therefore, a major implication of this alternative would be the requirement of modifying the wilderness management philosophy applied in the upper North Saskatchewan Basin, in order to better integrate these various uses, with minimal conflicts.

8.7.4 Alternative III (Wilderness Conservation Emphasis)

Selection of Alternative III would result in a considerable emphasis being placed upon wilderness conservation. Under this alternative, wilderness conservation and watershed management would be considered as co-dominant uses, with outdoor recreation being considered a secondary use. As with Alternatives I and II, wildlife and fisheries would be considered as tertiary uses. Implementation of this alternative would require a greater recognition of wilderness as a legitimate land use. This would require a trade-off of some degree of watershed management in order to facilitate increased wilderness conservation. For example, increasing the amount of land in the Basin designated as Wilderness Area, could limit some future opportunities for watershed improvement. The inclusion of lands on which potential damsites have been surveyed (Coral Creek, Cataract Creek, Cline River) could prevent the development of these sites, if required in the future. This may also limit some opportunities for interbasin transfer. However, these drawbacks may be possibly offset by development of other damsites downstream of Bighorn, or in other basins, such as the Red Deer Basin. Additional storage at Brazeau might also preclude the requirement to develop additional sites in the upper North Saskatchewan Basin. If structural watershed options were not required, potential conflicts between watershed management and wilderness conservation could be reduced considerably.

Maintenance of watershed conditions appropriate to meeting on-site and downstream water requirements would require extensive fire protection and infestation controls. This is perhaps the most critical issue in balancing watershed and wilderness objectives. Without a high degree of fire protection, watershed objectives of regime improvement and erosion control cannot be realized. However, application of these programs, along with sanitation cutting or selective thinning to maintain healthy vegetation for watershed improvement, could help to sustain 'wilderness' and would also have some secondary benefits for outdoor recreation and wildlife. Therefore, a change in wilderness management philosophies, policies, and strategies would be required under this alternative, to ensure that the co-dominant uses are compatible. Replacing the current biocentric wilderness management perspective (no environmental modification by man) with an anthropocentric perspective (active management to maintain wilderness for sustained use) should satisfy this requirement (Hendee, Stankey and Lucas, 1978).

The application of wilderness conservation and watershed management as dominant uses under this alternative, would limit some future outdoor recreation opportunities, especially intensive recreation. The emphasis placed on backcountry recreation would limit the extent of facility development. Only minimal expansion of existing campsites and development of staging areas to support backcountry activities would be considered. This would represent a major difference from the intensive facility developments proposed under Alternative II. In addition, backcountry use might also be controlled to prevent impact of recreational overuse in backcountry areas, especially within the Wilderness Areas. Limitation of use could also be appropriate to meeting watershed management objectives, by preventing accelerated soil erosion in key watershed areas.

Conjunctive use of the Abraham Lake reservoir for outdoor recreation would be acceptable under this alternative, providing that recreational facility development and subsequent use was not sufficient to impact the wilderness character of the North Saskatchewan River Valley or to conflict with reservoir operations. The Odyssey project, acceptable under Alternatives I and II, would not be acceptable under this alternative, because of the potential deterioration in wilderness values, resulting from a resort of this size, as well as the considerable increase in recreational use and development pressures which would occur in other areas of the Basin, due to the existence of this facility. Some modification of reservoir operations might also be required, to prevent any additional flooding of the Kootenay Plains Natural Area and to minimize deterioration in site aesthetics, resulting from drawdown.

Tertiary uses such as wildlife and fisheries might be less actively managed, in keeping with the wilderness philosophy. Management of wildlife populations and habitat improvement programs would not normally be required. However, where high ungulate populations result in watershed deterioration through accelerated erosion, control of populations could be required. Since fishing is prohibited in Wilderness Areas and vehicle access to backcountry lakes would not be provided, fish stocking and habitat improvement programs would not be necessary.

8.7.5 Alternative IV (East Slopes Policy Emphasis)

Selection of Alternative IV would make watershed the dominant land use, with wilderness, outdoor recreation, natural and cultural resource conservation and wildlife being co-secondary uses, of relatively equal value. Under this alternative, watershed protection would be emphasized, along with the preservation of environmentally sensitive terrain, rare biologic communities and critical wildlife range. Efforts would also be directed towards preservation of natural landscapes, with land use oriented towards dispersed backcountry recreation. No lands would be specifically allocated to watershed. However, by allocating lands to secondary uses, such as the preservation of environmentally sensitive terrain, protection of critical wildlife habitat or backcountry recreation, some degree of protection could be provided. It is assumed under this alternative that; by managing lands for such uses and applying an appropriate designation (e.g. provincial park, wilderness area, etc.), a high level of watershed protection is being provided. Although watershed is the dominant use, management of secondary uses may compromise the degree to which watershed conditions can be protected. Further, it is possible that this resource management strategy may not be appropriate to meeting the objectives defined for the upper North Saskatchewan Basin. However, this alternative does represent the current use and management situation. Therefore, one major implication of this alternative would be a high potential for significant resource management conflicts in the medium to long-term. These and other deficiencies in the East Slopes Policy have been outlined in considerable detail in earlier chapters.

Selection of this alternative would imply long-term allocation of lands to specific uses with relatively fixed, single-use management strategies being applied. The watershed management emphasis is on the maintenance of normal streamflow and water quality, to ensure a clean, reliable source of water for downstream users. However, the implication of management of secondary uses on watershed conditions, is not given any detailed consideration in the East Slopes Policy. It is therefore assumed by the author that any conflicts between the dominant use (watershed) and secondary uses would be dealt with on an 'as required' basis.

The ultimate implication of this alternative would be the possibility of arbitrarily changing secondary land uses or the way these uses are managed, in response to new water demands (e.g. constructing damsites in wilderness areas).

Conversely, this alternative may be acceptable under certain circumstances. For example, if the issue of more active watershed management or the need for additional damsites does not arise, this alternative may provide a viable resource management and land use strategy for the upper North Saskatchewan Basin. Therefore, the long-term implications of this alternative are difficult to assess at this point in time. However, because land use issues have not been addressed in any detail, management strategies have not been tied to specific, measurable objectives, and potential trade-offs have not been considered, it is anticipated that selection of this alternative would result in a greater potential for conflict than any of the previous three alternatives.

Alternative IV is perhaps most similar to Alternative III in terms of the management emphasis on wilderness conservation and watershed protection. However, a much greater emphasis is placed upon intensive recreational facility developments such as the Odyssey resort complex and possible downhill ski development. The emphasis placed upon active watershed management is much lower in Alternative IV than in either Alternative I or II. The emphasis placed upon wildlife is considerably greater in Alternative IV than in any of the other alternatives. On this basis, each of the four alternatives has considerably different implications for management.

8.8 Selecting the Best Alternative

Each of the alternatives described by the author could have some potential for application in the upper North Saskatchewan Basin. It must be re-emphasized that the alternatives proposed are mainly examples used to illustrate how the process works. A considerably greater range of alternatives would be possible and should be considered, in any actual resource management and land use planning exercise. In addition, only selected resource management and land use issues have been dealt with in this analysis and a considerably larger number of issues would have to be resolved in any actual plan developed for application in the study area.

For the purposes of this thesis, each alternative would have to be weighed carefully in relation to the defined goals, objectives and standards for the Basin. The basin-specific objectives and standards have been developed (hypothetically) within the environmental limitations of the upper North Saskatchewan Basin and in relation to both existing and projected resource development and land use demands. Therefore, the best alternative is the one which 'best-fits' or meets these defined objectives and standards.

Following selection of an appropriate alternative, a plan must be developed and an appropriate monitoring system established to measure progress towards the attainment of these objectives, to the standards specified. In the upper North Saskatchewan Basin, the level of monitoring required could be considerably greater than at present. This would basically require the completion of a detailed resource inventory and the establishment of an environmental monitoring system to measure changes in baseline conditions, following major changes in use, as well as measure the output of the upper North Saskatchewan Basin for water, hydro-power, outdoor recreation, wildlife, wilderness, protection of natural and cultural resources and other uses. An ongoing integration and evaluation of this information is also required, in order to determine whether or not the standards are being met for the duration of the plan and to identify deficiencies in relation to the standards. On the basis of this information, the plan can be modified, to ensure that the standards continue to be met for the life of the plan. Alternatively, this monitoring program may reveal that the standards cannot be realistically met. Therefore, some adjustments to the standards may also be required.

By developing a highly integrated resource management and land use plan, to meet defined goals, objectives and standards, a more complete utilization of available resources can be achieved, with fewer use conflicts. Measuring progress towards the attainment of defined objectives and standards, through an ongoing evaluation program should help to identify and alleviate significant environmental deterioration, associated with multiple-use, as well as minimize conflicts between uses. This level of integrated planning and management should improve long-term resource benefits for Albertans and ensure the maintenance of a high level of environmental quality.

9. Summary, Conclusions and Recommendations

9.1 Summary and Conclusions

Integrated, multiple-use land and resource management plans are required for all basins in the East Slopes. Such plans are necessary to minimize potential long-term land use and resource management conflicts. The deficiencies of the single-use approach currently used, have been outlined in detail earlier in this thesis, in chapters 3 and 6. A continuation of this single-use management approach could lead to long-term allocations of lands to very specific uses, in order to meet relatively short-term objectives. However, long-term land allocations, such as those suggested in the East Slopes Policy, may not be appropriate to meeting future demands (Alberta Government, 1984; 1977). Since these land allocations seem relatively inflexible, it could prove difficult to change these allocations and related management guidelines, in response to changing demands over time. This could become a major problem, given the present absence of measurable management objectives and a lack of any monitoring system or process, whereby progress toward the attainment of objectives can be measured. On the basis of these (and other) deficiencies inherent in the East Slopes Policy approach, a more comprehensive, integrated, multiple-use approach should be developed.

Historically, very little has been done to move toward a truly integrated approach to land use and resource management. The Eastern Rockies Forest Conservation Board recognized the importance of the interrelationship between land use and watershed conditions at an early stage. A considerable amount of research was completed by the Board during the "capital and planning period", between 1947-1955 (Hanson, 1973). However, the amount of watershed research, monitoring, and planning decreased significantly during the "maintenance" period, between 1955 and 1974, largely due to staff and budget limitations (Hanson, 1973).

Despite these limitations, a considerable volume of baseline environmental data was collected during the tenure of the E.R.F.C.B. and this was used by the Board to prepare general land use and resource management plans.

With the transfer of administrative responsibility to the Province of Alberta in 1973, considerable efforts were expended to collect biophysical information and evaluate land use capabilities in all East Slopes basins (Foothills Resource Allocation Study, 1973). The E.C.A. public hearings on land use and resource development in the East Slopes, resulted in considerable input relative to existing and potential uses of this region, as well as providing some indication of what the relative use priorities should be. However, despite these efforts, there was very little integration of material. Although land use capabilities were assessed for a variety of uses, this was done on a single-use basis. For example, no assessment of uses and capabilities under different conditions, such as different combinations and intensities of land use, was ever attempted. In effect, each potential land use was considered in isolation of all other potential uses. In many forest, soil and range surveys, some attempt was made to allow for "good watershed conditions", without defining what these conditions actually were. Perhaps the best example of this situation is the recognition of watershed as the prime use of the East Slopes, in many planning exercises, without much consideration of how a wide range of secondary land uses, might affect this prime use (Alberta Energy and Natural Resources, 1980a; Alberta Government, 1977; Foothills Resource Allocation Study, 1973; E.R.F.C.B., 1969).

This problem was further complicated by a poor definition of terms and objectives. For example, watershed management was never adequately defined. Therefore, no consideration of potential conflicts between watershed and other uses was possible, since some uses are compatible with or conflicting with watershed, depending on actual watershed requirements. This problem of definition still exists today. In current policy and planning documents, the relationship between land use and watershed conditions is not given adequate consideration. In the East Slopes Policy (1977) and revised East Slopes Policy (1984), a 'multiple-use' approach is implied, but this is not actually 'true' multiple-use. The allocation of large tracts of lands to fairly specific uses through zoning, implies more of a single-use approach. The labels attached to these zones, such as prime protection, critical wildlife, outdoor recreation, facility, etc., serve to reinforce this single-use orientation (Alberta Government, 1984; 1977). Although allowances are made for some compatible uses, such as backcountry recreation in the prime protection zone, no consideration is given to watershed as an actual land use. The potential effect of management for prime protection objectives on actual watershed requirements is not considered. This tends to be a self-defeating approach to management (e.g. defining a prime use, then outlining management guidelines which are not specifically oriented to managing for that use). This deficiency relates partially to a lack of defined watershed management objectives and a lack of objectives for other uses.

Another deficiency in the East Slopes Policy approach, is a failure to recognize the impacts of management on the Basin as a whole. For example, the effects of subdividing the East Slopes into several distinct zones and managing each zone differently (and independently) are not considered. Although the stated primary goal is; 'to ensure a reliable supply of clean water for aquatic habitat and downstream users', no consideration is given to the effect of land use and resource management activities in each zone, upon this stated watershed goal. (Alberta Government, 1984) Similarly, no consideration has apparently been given to the ecological relationships between lands in different zones. Management activities in one zone may have 'spillover' effects or indirect impacts in adjacent zones and this may limit the extent to which other uses can be optimized in the zones, especially along the boundaries between zones, where these impacts would be greatest.

These and other problems are also evident in many of the detailed planning documents prepared for the upper North Saskatchewan and other basins. For example, in the Rocky-Clearwater Management Overview, individual uses such as outdoor recreation, timber harvesting, wildlife, and fisheries are identified. However, very little consideration is given to the relative priorities of these various uses, or to potential management conflicts, or the possibility of trade-offs in the long-term, as demands begin to exceed resource supply.

The management strategy applied to land use and resource development in the East Slopes could result in potential use conflicts in the medium to long-term. The basis for these potential conflicts in the upper North Saskatchewan Basin has been discussed extensively in chapters 3 through 6 of this thesis. Similar conflicts could also occur in other East Slopes basins such as the Bow, Athabasca and Oldman. However, the potential for serious conflicts could be much higher in these other basins. Land use activity in the upper North Saskatchewan Basin is fairly limited at present, with recreational overuse of the North Saskatchewan Valley being the most critical problem at the present time (Alberta Energy and Natural Resources, 1980). However, land use activities and resource developments in the other East Slopes basins are much more intensive, and a greater range of uses is encouraged. Therefore, it would be logical to assume that potential management conflicts could occur in these basins, within a much shorter time-frame than in the upper North Saskatchewan Basin. In addition, these conflicts could be of a more serious nature. The limitations of the East Slopes Policy (single-use) management approach would become even more evident, if this same type of problem analysis were applied to these other basins. Other land uses, such as mining, oil and gas, industry, agriculture, timber harvesting and similar types of extractive use, present to some degree in the other East Slopes basins, would increase the complexity of land use and resource management problems. Potential solutions to these problems would also be fairly complex. Since the East Slopes Policy approach is ineffective for solving relatively basic land use and resource management problems in the upper North Saskatchewan Basin, one could conclude that this approach would also be totally inadequate for application in other basins, having considerably more complex and intensive uses and use problems.

The limitations of the East Slopes Policy and current resource management and land use planning approaches have been outlined in various sections. Because of these deficiencies, a more comprehensive, integrated approach to planning and management should be applied in managing the East Slopes. Many different approaches are possible, including the use of the process suggested by the author in chapter 7 and 8. However, in order to ensure effective management, certain fundamental principles must be recognized, irrespective of the approach used. It must be recognized that in some East Slopes Basins, most notably the Bow, Athabasca, and Oldman, land use pressures for a wide range of uses are increasing fairly rapidly. Therefore, there is an important long-term requirement for detailed, integrated, multiple-use plans for all East Slopes Basins. Work on such plans should be initiated as soon as possible, using a different approach than the one implied in the East Slopes Policy. This is necessary in order to minimize long-term resource management and land use conflicts in all East Slopes Basins.

The physical resource differences between and within different basins must also be recognized. Individual basins and different portions of these basins may have different values (capabilities to sustain different uses) and these must be identified in order to establish use priorities and to assess the potential for conflict between uses. Even more basic is the concept that regional differences in the physical resource base may result in regional differences in each use (Laycock, 1957a). For example, a humid, densely forested, drift soil area may have a high capability for timber production, water production and certain types of recreational use (Pettapiece, 1971; Laycock, 1957a). In contrast, a dry grassland area with thin residual soils may have a high capability to sustain uses such as wildlife, grazing, and different types of recreational activities than are possible in a forested area, and may be more important for regime than for water yield (Laycock, 1957a). Due to these very considerable differences, management of both areas for the same use(s) and use priorities is not realistic. However, under the East Slopes Policy zoning framework, delineation of broad zones, which transcend watershed boundaries, and the application of the same uses, use priorities and management guidelines, to all lands within the same zone, is encouraged. This is a major limitation to the effectiveness of the East Slopes Policy relative to resource management and land use.

All existing and potential uses should be identified in relation to these differences and in relation to the different resource management and land use problems. A useful approach might be to differentiate three or more broad watershed zones for each basin (e.g. headwaters, intermediate, and valley) and then evaluate specific problems within each zone, on the basis of physical differences. It is also recommended that these watershed zones be further sub-divided into specific land units, to permit a more detailed assessment of local limitations to use and to identify specific management problems within each basin. It would be very useful to define specific areas that will respond to intensive management for yield improvement, regime improvement, flood control, water quality, timber production, intensive recreation, forage, wildlife and many other uses. This assessment would have to be considerably more detailed than the assessment which was completed as part of the Foothills Resource Allocation Study (1973). Under such an assessment, watershed conditions must be evaluated for the various outputs, such as yield, regime, quality, erosion, etc., and other land uses must be equally well-defined. For example, recreation should be sub-divided into separate activities, with an individual capability assessment completed for each activity. This is especially important since a given land unit may have a high capability to sustain one recreational activity, but have a low capability to sustain another, due to the different land requirements of various activities. The potential uses of various watershed zones and land units within these zones, will largely depend upon the capability of the soil to sustain various uses, without damage to the required watershed conditions (Pettapiece, 1971; Laycock, 1957a). It is therefore recommended that detailed soil classifications, such as the one completed by Pettapiece (1971) in the upper North Saskatchewan Basin, be used as a basis for identifying and evaluating the capabilities of specific land units in each watershed zone, in each basin. Other studies such as vegetation, wildlife, and land use, can be combined with this soils information, to provide a good indication of environmental conditions and use capabilities. Capabilities for all potential uses and any potential limitations to the capability of a given land unit to sustain a given use, in different multiple-use situations, should be identified on the basis of this information. This would provide a relatively detailed indication of the range of uses possible within each basin. In addition, specific limitations to use under different management strategies should be identified (e.g. What happens to the capability for ungulates, when a downhill ski facility is developed on the same land unit?)

Detailed demand information must also be available for all basins. Some demand information has already been collected under such programs as the East Slopes Public Hearings (1973), but considerably more refined and detailed information is required for all potential uses in each basin. It is recommended that wherever possible, such demand information be quantifiable and capable of being projected into the future, to permit long-term planning. This should provide some indication of current and future demands in each basin. Some degree of assessment of changing demands in the short, medium and long-term should also be possible, on the basis of this information.

Once this level of resource supply and demand information has been collected for each basin, priorities for use within the East Slopes, within each basin and within specific zones in each basin, can be determined. Since watershed is recognized as the prime use in all East Slopes basins, its importance must be recognized in any such evaluation. Specific watershed management objectives must be defined for each basin (e.g. yield improvement, regime improvement, etc.) based on resource supply, demand and physical opportunities for change through management. Objectives must also be defined for all other potential uses in each basin, on the basis of use capability and demand information. Once these objectives have been defined, it should be possible to evaluate and priorize other uses in each basin, in relation to defined watershed management objectives.

An alternative futures approach to land use and resource management planning is recommended for all basins in the East Slopes. Under this approach, alternative management strategies can be developed to outline different combinations, intensities and priorities of land use within each basin. In the development of alternatives, the limitations, conflicts and possible trade-offs could be identified for each use or group of uses. On this basis, potential impacts of various secondary uses and related management strategies, could be assessed in terms of potential conflicts with watershed. It should therefore be possible to predict potential impacts of use on watershed conditions or possible limitations to watershed management at different points in time. This should permit a more rational choice of alternatives. On this basis, the best alternative in relation to overall demands within the basin, within the region, and in areas downstream, should be selected for implementation.

In the past, management has usually ended with the implementation and administration of a land use and resource management plan. However, this is not adequate for managing complex multiple-use situations. Measures must be established to determine whether or not the stated objectives are being met for each use, for the duration of the plan. This requires the establishment of a monitoring, feedback and evaluation system, to ensure that the alternative selected continues to meet demands, in the most effective way, in relation to the defined objectives.

Ongoing research programs are also recommended for all basins. Continued research is necessary in order to evaluate changing conditions and to evaluate opportunities for improvement in resource conditions and use patterns under different use situations. Research into the effects of different management strategies and techniques in different basins, could be of considerable benefit. For example, studies into the effects of non-use, or light, moderate or heavy use for ungulates, recreation, grazing, development or other uses; the effects of fire and forest harvesting on watershed conditions in different basins, and changes in these patterns, could be useful in determining the potential impact of land use practices on watershed values and on other uses (Laycock, 1957a).

Comprehensive, multiple-use planning could be very effective in the East Slopes, especially in the long-term, if priorities are established on the basis of sound information, such as inventories of resources, use, supply and demands. Well-defined objectives for each use can improve the effectiveness of such an approach considerably, as the absence of well-defined objectives is a major deficiency in the current East Slopes Policy. Land use and resource management planning cannot be effective in situations where objectives are poorly defined and baseline information is at a very general level, or in situations where the environmental relationships and differences between land units are poorly understood. Therefore, to overcome these and other deficiencies, other management approaches should be considered in the management of land use and resource development in the East Slopes.

9.2 Recommendations For Managing the Upper North Saskatchewan Basin

The upper North Saskatchewan Basin has the potential to sustain a fairly narrow range of land uses. However, a considerable range is possible in terms of the combinations of these uses, use intensities and potential management strategies. Watershed management, to ensure maintenance of favourable regime patterns and water quality, should be the most important use. All land uses, combinations and levels of use, and the management strategies applied, should be complementary to watershed management objectives. The study area also contains some of the best potential areas for outdoor recreation in the East Slopes. Although the area is already heavily used for a wide range of dispersed activities, mostly on an informal basis, ever-increasing demands require effective management of this use. If recreational use is not carefully managed, uncontrolled use will result in a rapid deterioration in aesthetic qualities and in watershed conditions. The creation of the White Goat and Siffleur Wilderness Areas and Kootenay Plains Natural Area has resulted in significant portions of the study area being protected from development. These designations have also resulted in these areas being protected from other use impacts and has provided for the conservation of significant landscapes and features. Specific management guidelines are required for these areas in order to continue to meet conservation objectives as well as ensuring that management of these areas is consistent with watershed management and outdoor recreation objectives.

In order to meet these different objectives with minimal use conflicts, the following recommendations are suggested for the upper North Saskatchewan Basin. All existing and potential uses should be inventoried and evaluated. All areas and potential uses should be assessed in terms of importance to watershed, the watershed function of the land unit, opportunities for maintenance or improvement upon existing conditions and potential impacts upon these opportunities, with different types, levels and combinations of land use. Such an assessment should address the potential for yield, regime and quality maintenance and/or improvement. Opportunities for water resource development, inter-basin transfer and other such options should also be assessed on this same basis. Areas of the basin which have deteriorated with existing use should also be identified and potential reclamation requirements should be evaluated. Priorities for watershed protection should be identified, partially on the basis of erosion potential, and land use guidelines established for each priority (e.g. no use, restricted use, etc.). On this basis, a detailed watershed capability map could be developed. Such a map would serve to identify specific land units within each watershed management zone (headwaters, intermediate, valley), which would have a high, medium, or low capability to sustain various secondary land uses.

All recreation development options should be assessed in relation to the capability of different areas of the Basin to sustain different types of recreational use. Since recreational activities have different requirements, different degrees of environmental impact and different degrees of potential for conflict with watershed management, a capability assessment should be completed for each potential recreational activity (e.g. auto-access camping, hiking, equestrian use, mountaineering, downhill skiing, etc.). This approach would require a greater level of detail than was used in the outdoor recreation capability assessment, completed as part of the Canada Land Inventory program (Foothills Resource Allocation Study, 1973). Use of such a detailed assessment would permit a more realistic appraisal of land use capability. On this basis, potential conflicts with watershed and other uses could be more easily identified.

Similar detailed inventories and assessments should also be completed for significant natural and cultural resources and for lands within the existing Wilderness Areas. Resource conservation and wilderness management options should also be evaluated in relation to other uses of the Basin and in relation to the requirements of protecting these areas and/or managing their use. Such an assessment could include an evaluation of the effects of a management strategy emphasizing an anthropocentric philosophy as opposed to a biocentric philosophy (managed use vs. preservation). Potential conflicts between wilderness and other uses, especially watershed, could then be evaluated in relation to various wilderness management strategies. Priorizing natural and cultural resources, in terms of their relative significance, is also recommended, in order to determine the level of potential conflict between conservation objectives and other uses, in specific areas of the Basin. For example, destruction of a geological feature having national or international significance, resulting from increased flow regulation, would cause considerably greater conflicts, than would the loss of a feature of lesser significance, under the same circumstances (e.g. a representation of the montane ecological region, which may also be represented in other areas).

Inventories and evaluations of other potential uses, including those having only a remote possibility, should also be considered. It is recommended that detailed evaluations also be completed for wildlife, oil and gas, coal, grazing, and commercial forestry, even though many such uses are not currently viable. Wildlife assessments may provide the basis for identifying areas of the Basin which are overbrowzed, resulting in watershed damage and may also serve to identify optimal ungulate population levels. Potential conflicts with other uses and possibilities for enhancement through other uses, could also be identified. Grazing assessments, could give some indication of the capability for commercial grazing, which could be integrated with ungulate range data, to get a better indication of carrying capacity. Assessments for forestry may be useful to determine the potential for conjunctive forestry and watershed management programs, especially in the eastern end of the study area, even though merchantable stands are not extensive. This type of assessment may also provide information for watershed improvement programs, by identifying over-mature stands which should be harvested to maintain stand age/species diversity and healthy vegetation. Such areas could be identified and potential benefits, costs, and conflicts with other uses, could be evaluated for different areas of the Basin.

Many of the inventory requirements identified above could be met by existing studies. However, this information is deficient in two main areas. Firstly, much of the available information is 15 to 20 years old, and may not reflect current conditions in the Basin (e.g. vegetation, wildlife, soil erosion potential, recreational use, etc.). Therefore, it is recommended that this information be updated and expanded to an acceptable level of detail, as described earlier in this section. Secondly, past inventories have been completed essentially for a single-use or purpose and in relative isolation of other uses or variables. No consideration has ever been given to potential changes in the capability of a land unit to sustain one use, in the presence of other uses. For example, how much capability to sustain wildlife will be lost, if a roadway is constructed in the area? What loss in watershed capability can be expected in an area, if a 100% increase in recreational use occurs, a 500% increase, different types of activities, or if different land units are involved? What is really needed here, is an assessment of the capability for each use, under different management strategies, emphasizing different types, combinations and intensities of use. By developing such an assessment system, the capabilities of a given land unit, as well as indirect impacts in adjacent land units, could be more accurately predicated, for different land use and resource management situations. This level of assessment would permit a more realistic evaluation of land use capabilities, in a multiple-use situation, and would permit a more realistic assessment of potential use limitations and conflicts.

Resource information at this level of detail, would also provide the basis for defining detailed management objectives. If the land use capabilities to sustain multiple uses are known, objectives can be defined, which are attainable within these limitations. Baseline conditions can be established and the conditions to be achieved through management can be identified. By identifying, existing and potential interrelationships between uses (change in land use capability for a single use, in the presence of other uses), resource managers should be able to assess use capabilities, limitations and conflicts under different management strategies. This will provide the means to develop alternative management strategies or futures, to meet defined objectives within an identified timeframe.

An alternative futures approach such as the one described in chapters 7 and 8 of this thesis is recommended for the upper North Saskatchewan Basin. However, the success of this approach is highly dependent upon detailed resource information, as described earlier in this section. It is therefore recommended that this information be evaluated, inconsistencies or 'gaps' in the information be identified, and steps taken to collect and integrate any missing information. Collection of this information may be required periodically in order to measure changes resulting from the application of a management strategy. Therefore, monitoring and evaluation systems should also be established at this time and the extent of these systems should be proportional to the extent of land use changes proposed and to the degree of potential impacts and conflicts.

A much wider range of objectives and more detailed management issues than have been considered by the author, must be included in any actual land use and resource management plans developed for the Basin. Careful consideration of these issues in relation to resource demands, available supply, and limitations to this supply under different management approaches, and potential changes to these patterns is required, in order to select an appropriate alternative for implementation.

The implementation of a preferred alternative to meet defined objectives and standards may also require on-going monitoring of progress. Interpretation and understanding of the information collected through monitoring is required to measure progress towards meeting the stated objectives to the specified standards. On this basis, decisions on whether objectives are being met and on whether to continue, modify, or discontinue the strategy being applied in the Basin, can be made.

In conclusion, use of a multiple-use 'alternative futures' approach, as outlined in this thesis, would have considerable benefits over the essentially single-use management approach, currently applied in the upper North Saskatchewan Basin and East Slopes Region in general. The benefits (and limitations) of this approach have been described in detail by the author. Although adequate in the past, the single-use approach will surely break down in the future, with the potential effect of significant resource management and land use conflicts, misallocations of resources and less than optimum use benefits being obtained from use of the East Slopes Region. Effective land use and resource management, through a process such as the one outlined in this thesis, would therefore be of considerable benefit in the long-term.

Although such an approach is not 'perfect' and despite some major limitations, it is recommended as a viable alternative to the single-use approach currently in use.

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